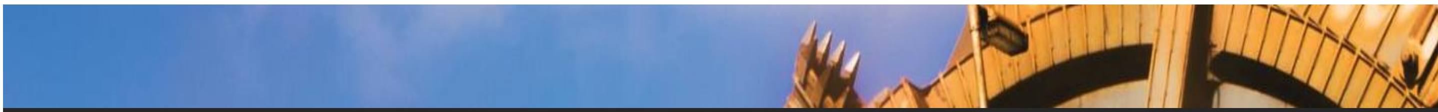

Koolyanobbing Iron Ore Project

MS982 ANNUAL COMPLIANCE ASSESSMENT REPORT 2018

Proponent:	Yilgarn Iron Pty Ltd
Address:	1 Sleat Road, Applecross, WA 6153
Postal Address:	Locked Bag 3, Canning Bridge LPO, Applecross, WA 6153
Contact:	Tim Berryman
Phone:	+61 8 9329 3713
Email:	Timothy.Berryman@mrl.com.au

April 2019

Report Reference: ENV-TS-RP-0130_0

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Revision History

Revision Number	Issue Date	Prepared By	Distribution	Status
A	15/04/2019	M. Flowers	N. Smith	Draft for Internal Review
B	17/04/2019	M. Flowers	N. Smith / T.Berryman	Final for Internal Review
0	26/04/2019	M. Flowers/N. Smith	DWER	Final

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FIGURES

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1. INTRODUCTION

1.1 Project Overview

Mining has occurred at Koolyanobbing since the 1960's. Formally known as Portman Iron Ore, Cliffs Asia Pacific Iron Ore Pty Ltd (Cliffs) recommissioned the operations following closure by BHP Pty Ltd in the early 1980's and operated the mine from 1994 until 2018.

Cliffs ceased mining operations at Koolyanobbing in early 2018 and entered into an Asset Sale Agreement with Mineral Resources Limited (MRL) on 12 June 2018. The transaction was completed in August 2018 and included the transfer of legal title in Cliffs mining tenements to MRL and ownership of all remaining iron ore, fixed plant, equipment and non-process infrastructure in the Yilgarn and at the Port of Esperance. All assets were transferred to the wholly owned MRL subsidiary Yilgarn Iron Pty Ltd (YIPL).

YIPL commenced mining at Koolyanobbing in September 2018. Iron ore is mined from a number of open pits, blended, crushed and screened to make products that meet export market specifications. Ore from the northern operations of Deception, Mt Jackson and Windarling is transported via a private haul road to Koolyanobbing where it is selectively blended with ore from Koolyanobbing, crushed, and screened to meet market specifications. The final product is transported from Koolyanobbing to Esperance Port by rail.

1.2 The Proponent

Following the Asset Sale Agreement and pursuant to section 38(6) and (7) of the *Environmental Protection Act 1986 (WA)* (EP Act), YIPL was nominated as the person responsible for the Proposal (Yilgarn Operations – Windarling Range, Mt Jackson Range and Deception Deposit; Assessment No. 2011; Statement No. 982).

YIPL is a wholly owned subsidiary of MRL and became the beneficial holder of the mining tenements for the Koolyanobbing Iron Ore Project.

1.3 Approvals History

From 2003 to 2012, the Yilgarn Operations were regulated by seven Statement approvals issued by the Western Australian Minister for Environment under s45 (5) under the EP Act. In September 2012, Cliffs was approached by the Office of the Environmental Protection Authority (OEPA) to investigate the potential of consolidating the above seven Statements into a single document. This approach by OEPA was prompted by an enquiry from the Minister for Environment as a result of a number of Statement approvals for connected mine operations being issued in late 2012.

Cliffs was granted environmental approval for the consolidation of previous statements under both s45C and s46 of the EP Act on 24 September 2014 through *Ministerial Statement 982* (MS982). Responsibility for this Proposal was transferred to YIPL in the third quarter of 2018, following the Asset Sale Agreement between Cliffs and MRL.

1.4 Ministerial Statement MS982

MS982 outlines conditions regulating the mining of iron ore at YIPL's northern Yilgarn Operations, which includes Windarling Range (W1, W2, W3/5, W4 West and W4 East), Mt Jackson Range (J1, J2 and J3) and Deception Deposit. These operations are located approximately 70, 100 and 120 km north of Koolyanobbing respectively (see Figure 1 for general locations).

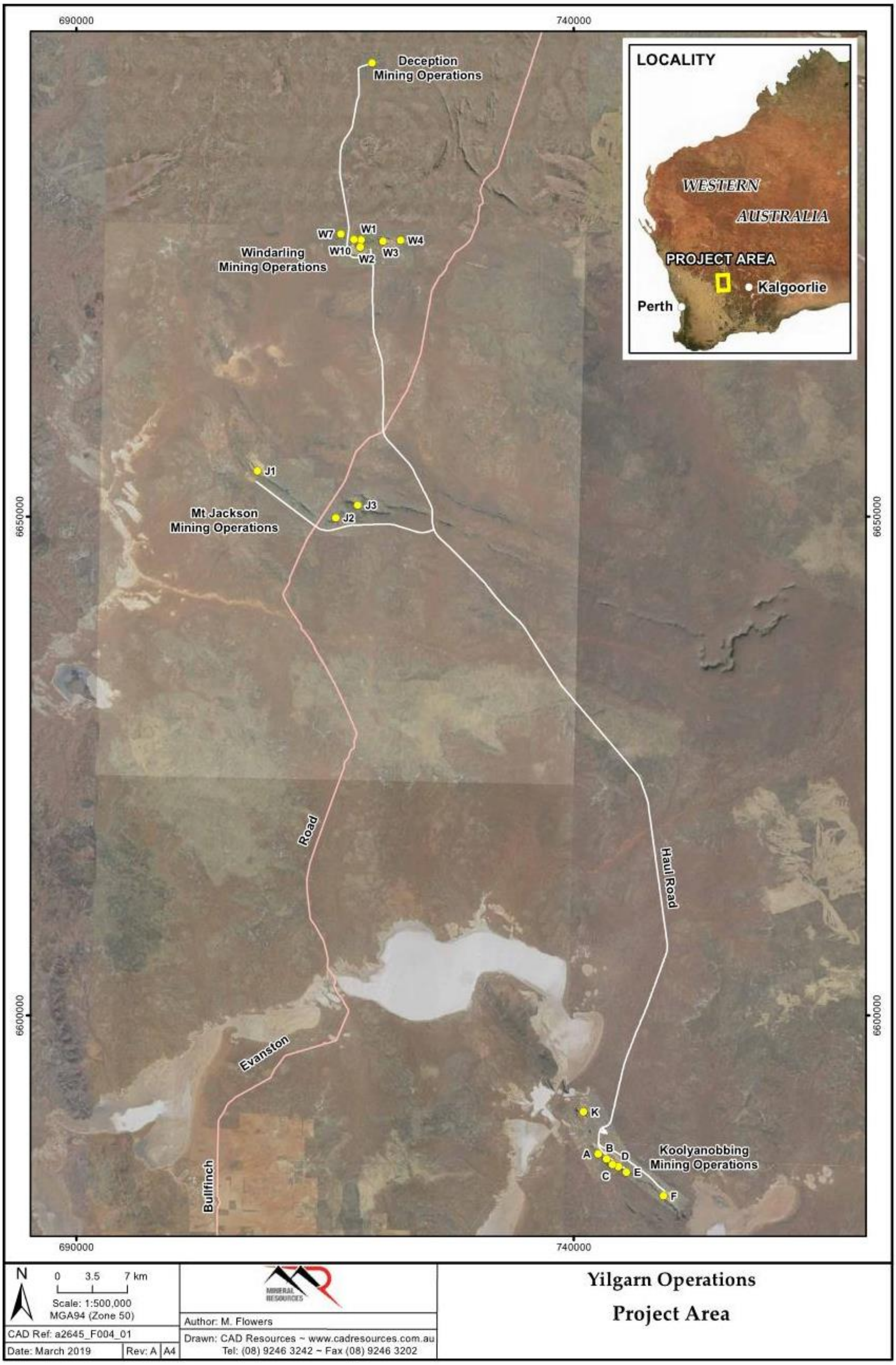


Figure 1 - General Location of YIPL Yilgarn Operations

Condition 3.6 of MS982 states:

The proponent shall submit to the CEO an annual Compliance Assessment Report by 30 April of each year, or as otherwise agreed by the CEO, addressing the period of the preceding calendar year. The compliance assessment report shall:

1. *Be endorsed by the proponent's Managing Director/General Manager/Chief Executive Officer or a person delegated to sign on the Managing Director's/General Manager's /Chief Executive Officer's behalf;*
2. *Address the Proponent's compliance with each condition of this Statement;*
3. *Describe corrective and preventative actions taken in the event of a non-compliance;*
4. *Indicate any proposed changes to the Compliance Assessment Plan required by Condition 3.1.*

This Annual Compliance Assessment Report was prepared in accordance with *Condition 3.6* of MS982 for the period between 1 January and 31 December 2018. It takes into consideration that there were two proponents responsible for this Proposal during the reporting period – Cliffs and YIPL.

2. PROJECT STATUS

The Windarling, Mt Jackson, and Deception operations continued during the 2018 reporting period. Operations temporarily ceased for part of the year due to Cliffs ceasing operations. Mining re-commenced in late 2018 following the Asset Sale Agreement between Cliffs and MRL.

3. COMPLIANCE

3.1 Non-compliance and Corrective Actions

No non-compliances were recorded during the 2018 reporting period.

3.2 Statement of Compliance

YIPL has complied with all conditions of Ministerial Licence 982 for the 2018 reporting period. Refer to *Attachment 1 – 2018 Statement of Compliance for MS982.*

4. DETAILS OF DECLARED COMPLIANCE STATUS

Assessment of Compliance – Ministerial Statement MS982 Audit Table (Attachment 2) provides the compliance status of each implementation condition for the 2018 reporting period.

Attachment 1 – 2018 Statement of Compliance for MS982

Statement of Compliance

1. Proposal and Proponent Details

Proposal Title	*Yilgarn Operations – Windarling Range, Mt Jackson Range and Deception Deposit Assessment No. 2011*
Statement Number	*MS982*
Proponent Name	*Yilgarn Iron Pty Ltd. (nominated as person responsible under S38(6) and 38(7) of the EP Act)*
Proponent's Australian Company Number *(where relevant)*	ACN: 626 035 078

2. Statement of Compliance Details

Reporting Period	*1/01/18* to *31/12/18*

Implementation phase(s) during reporting period (please tick ✓ relevant phase(s))							
Pre-construction		Construction		Operation	✓	Decommissioning	

Audit Table for Statement addressed in this Statement of Compliance is provided at Attachment:	2
An audit table for the Statement addressed in this Statement of Compliance must be provided as Attachment 2 to this Statement of Compliance. The audit table must be prepared and maintained in accordance with the Department of Water and Environmental Regulation (DWER) *Post Assessment Guideline for Preparing an Audit Table*, as amended from time to time. The 'Status Column' of the audit table must accurately describe the compliance status of each implementation condition and/or procedure for the reporting period of this Statement of Compliance. The terms that may be used by the proponent in the 'Status Column' of the audit table are limited to the Compliance Status Terms listed and defined in Table 1 of Attachment 1.	

Were all implementation conditions and/or procedures of the Statement complied with within the reporting period? (please tick ✓ the appropriate box)			
No (please proceed to Section 3)		Yes (please proceed to Section 4)	✓

3. Details of Non-compliance(s) and/or Potential Non-compliance(s)

The information required Section 3 must be provided for each non-compliance or potential non-compliance identified during the reporting period covered by this Statement of Compliance.

Non-compliance/potential non-compliance 3-1

Which implementation condition or procedure was non-compliant or potentially non-compliant?
Was the implementation condition or procedure non-compliant or potentially non-compliant?
On what date(s) did the non-compliance or potential non-compliance occur (if applicable)?

Was this non-compliance or potential non-compliance reported to the Chief Executive Officer, DWER?	
☐ Yes ☐ Reported to DWER verbally Date ___________ ☐ Reported to DWER in writing Date ___________	☐ No

What are the details of the non-compliance or potential non-compliance and where relevant, the extent of and impacts associated with the non-compliance or potential non-compliance?
What is the precise location where the non-compliance or potential non-compliance occurred (if applicable)? (please provide this information as a map or GIS co-ordinates)
What was the cause(s) of the non-compliance or potential non-compliance?
What remedial and/or corrective action(s), if any, were taken or are proposed to be taken in response to the non-compliance or potential non-compliance?
What measures, if any, were in place to prevent the non-compliance or potential non-compliance before it occurred? What, if any, amendments have been made to those measures to prevent re-occurrence?
Please provide information/documentation collected and recorded in relation to this implementation condition or procedure: • in the reporting period addressed in this Statement of Compliance; and • as outlined in the approved Compliance Assessment Plan for the Statement addressed in this Statement of Compliance. (the above information may be provided as an attachment to this Statement of Compliance)

For additional non-compliance or potential non-compliance, please duplicate this page as required.

Each page (including Attachment 2) must be initialed by the person who signs Section 4 of this Statement of Compliance.
INITIALS: NJ

4. Proponent Declaration

I, TIMOTHY BERRYMAN GENERAL MANAGER TECH SERVICES *(full name and position title)* declare that I am authorised on behalf of YILGARN IRON PTY LTD .... *(being the person responsible for the proposal)* to submit this form and that the information contained in this form is true and not misleading.

Signature:.. Date: 18/4/19 ....

Please note that:

- it is an offence under section 112 of the *Environmental Protection Act 1986* for a person to give or cause to be given information that to his knowledge is false or misleading in a material particular; and
- the Chief Executive Officer of the DWER has powers under section 47(2) of the *Environmental Protection Act 1986* to require reports and information about implementation of the proposal to which the statement relates and compliance with the implementation conditions.

5. Submission of Statement of Compliance

One hard copy and one electronic copy (preferably PDF on CD or thumb drive) of the Statement of Compliance are required to be submitted to the Chief Executive Officer, DWER, marked to the attention of Manager, Compliance (Ministerial Statements).

Please note, the DWER has adopted a procedure of providing written acknowledgment of receipt of all Statements of Compliance submitted by the proponent, however, the DWER does not approve Statements of Compliance.

6. Contact Information

Queries regarding Statements of Compliance, or other issues of compliance relevant to a Statement may be directed to Compliance (Ministerial Statements), DWER:

Manager, Compliance (Ministerial Statements)

Department of Water and Environmental Regulation

Postal Address:	Locked Bag 33 Cloisters Square PERTH WA 6850
Phone:	(08) 6364 7000
Email:	compliance@dwer.wa.gov.au

7. Post Assessment Guidelines and Forms

Post assessment documents can be found at www.epa.wa.gov.au

ATTACHMENT 1

Table 1 Compliance Status Terms

Compliance Status Terms	Abbrev	Definition	Notes
Compliant	C	Implementation of the proposal has been carried out in accordance with the requirements of the audit element.	This term applies to audit elements with: • ongoing requirements that have been met during the reporting period; and • requirements with a finite period of application that have been met during the reporting period, but whose status has not yet been classified as 'completed'.
Completed	CLD	A requirement with a finite period of application has been satisfactorily completed.	This term may only be used where: • audit elements have a finite period of application (e.g. construction activities, development of a document); • the action has been satisfactorily completed; and • the DWER has provided written acceptance of 'completed' status for the audit element.
Not required at this stage	NR	The requirements of the audit element were not triggered during the reporting period.	This should be consistent with the 'Phase' column of the audit table.
Potentially Non-compliant	PNC	Possible or likely failure to meet the requirements of the audit element.	This term may apply where during the reporting period the proponent has identified a potential non-compliance and has not yet finalized its investigations to determine whether non-compliance has occurred.
Non-compliant	NC	Implementation of the proposal has not been carried out in accordance with the requirements of the audit element.	This term applies where the requirements of the audit element are not "complete" have not been met during the reporting period.
In Process	IP	Where an audit element requires a management or monitoring plan be submitted to the DWER or another government agency for approval, that submission has been made and no further information or changes have been requested by the DWER or the other government agency and assessment by the DWER or other government agency for approval is still pending.	**The term 'In Process' may not be used for any purpose other than that stated in the Definition Column.** The term 'In Process' may not be used to describe the compliance status of an implementation condition and/or procedure that requires implementation throughout the life of the project (e.g. implementation of a management plan).

Each page (including Attachment 2) must be initialed by the person who signs Section 4 of this Statement of Compliance.
INITIALS: ______

Attachment 2 – Assessment of Compliance – Ministerial Statement MS982 Audit Table

Audit Table

Yilgarn Operations – Windarling Range, Mt Jackson Range and Deception Deposit – Shire of Yilgarn and Shire of Menzies (Statement 982)

- Phases that apply in this table = Pre-Construction, Construction, Operation, Decommissioning, Overall (several phases).
- The Audit Table provides a summary interpretation of the condition requirements applying to the Proposal under the *Environmental Protection Act 1986* (WA). Please refer to the Statement approval issued for the Proposal for the agreed condition wording and abbreviations.
- Status: C = Compliant; CLD = Completed; NC = Non – compliant; NR = Not Required at this stage; NA = Not Audited; VR = Verification Required; IP = In Process.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
982:M1.1	**Proposal Implementation**	When implementing the proposal, the proponent shall not exceed the authorised extent of the proposal as defined in Column 3 of Table 2 in Schedule 1, unless amendments to the proposal and the authorised extent of the proposal have been approved under the *Environmental Protection Act 1986* (EP Act).	Project implemented to limits described in Column 3 of Table 2.	Compliance Assessment Report (CAR)	Overall	Annually 30th April	C	The proposal is implemented to requirements described in Column 3 of Table 2 as described in 982:M1.1
		Key Characteristic		**Description**				
982:M1.1.1	**Proposal Implementation**	Land clearing and mining below groundwater level		Windarling Mine Pits – (1) No more than 266 ha (2) W1 East, W1 West, W2, W3/5, W7 and W10 to be mined below the groundwater table (3) W2 to be backfilled above the groundwater table (4) W4 West and W4 East to be mined above the groundwater table			C	(1) To date, 187 hectares of land has been progressively cleared for Windarling Pits. (2) W1 East, W1 West, W2, W3/5 have been mined below the groundwater table. Clearing activities were undertaken at W7 and W10 pits in 2017. MRL commenced mining of W7 and W10 in the third quarter of 2018. (3) Some waste material has been backfilled into W2. (4) Both W4 West and W4 East pits were mined above the groundwater table. W4 West was backfilled and converted into a Waste Rock Landform. W4 East has been partially backfilled See Attachment 3 Windarling Clearing Note 1: Clearing GIS spatial data will also be submitted with this report as electronic shape files.
		Land clearing and mining below groundwater level		Mt Jackson Mine Pits – (1) No more than 133 ha (2) J1 East, J2 and J3 to be mined above groundwater table (3) J1 West to be mined below groundwater table			C	(1) To date, 108 hectares of land has been progressively cleared for Mt Jackson Pits. (2) J1 East is currently being mined above the groundwater table, mining is complete at J2 and J3, both pits were mined above the groundwater table. (3) J1 West has been mined below groundwater table. See Attachment 4 Mt Jackson J1 Clearing and Attachment 5 Mt Jackson Clearing Note: Clearing GIS spatial data will also be submitted with the report as electronic shape files.
		Land clearing and mining below groundwater level		Deception Pits – (1) No more than 118 ha (2) Deception Deposit to be mined below groundwater table			C	(1) To date, 30 hectares of land has been progressively cleared for the Deception Pits. (2) Mining continued in the Deception Deposit but the deposit has not been mined below the groundwater table. See Attachment 6 Deception Clearing

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
								Note: Clearing GIS spatial data will also be submitted with the report as electronic shape files.
		Land Clearing		Windarling Waste Rock Landforms – Not more than 433 ha			C	To date, 308 hectares of land has been progressively cleared for Windarling Waste Rock Landforms. See Attachment 3 Windarling Clearing
		Land Clearing		Mt Jackson Waste Rock Landforms – Not more than 263 ha			C	To date, 215 hectares of land has been progressively cleared for Mt Jackson Waste Rock Landforms. See Attachment 4 Mt Jackson J1 Clearing and Attachment 5 Mt Jackson Clearing
		Land Clearing		Deception Deposit Waste Rock Landforms – Not more than 258 ha			C	To date, 41 hectares of land has been progressively cleared for Deception Deposit Waste Rock Landforms. See Attachment 6 Deception Clearing
		Land clearing		Associated Infrastructure - Windarling - Not more than 235 ha, including 25.1 ha for Windarling Range Airstrip and 6 ha for road train haulage parking area			C	To date, 185 hectares of land has been progressively cleared for Associated Infrastructure – Windarling. This includes 24 hectares for Windarling Range Airstrip and 4.4 hectares for road train haulage parking area. This also includes clearing undertaken for access to the W7 and W10 deposits. See Attachment 3 Windarling Clearing
		Land clearing		Associated Infrastructure – Mt Jackson - Not more than 259 ha			C	To date, 113 hectares of land has been progressively cleared for Associated Infrastructure – Mt Jackson. See Attachment 4 Mt Jackson J1 Clearing and Attachment 5 Mt Jackson Clearing
		Land clearing		Associated Infrastructure – Deception Deposit – Not more than 53 ha			C	To date, 42 hectares of land has been progressively cleared for Associated Infrastructure – Deception Deposit. See Attachment 6 Deception Clearing
		Land clearing		Haul Roads – Not more than 609 ha			C	To date, 570 hectares of land has been progressively cleared for Haul Roads. Totals cleared for each section are detailed below. Koolyanobbing Haul Road- 349 hectares Windarling Haul Roads – 83 hectares Mt Jackson Haul Roads – 65 hectares Deception Deposit – 73 hectares See Attachment 7 Haul Road Clearing

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
982:M2.1	**Contact Details**	The proponent shall notify the CEO of any change of its name, physical address or postal address for the serving of notices or other correspondence within 28 days of such change. Where the proponent is a corporation or an association of persons, whether incorporated or not, the postal address is that of the principal place of business or of the principal office in the State.	Written notification	Correspondence notifying the CEO / Director General – DWER of change to name or address	Overall	Within 28 days of such change.	NR	Cliffs entered into an asset sale agreement with Mineral Resources Limited Pty Ltd (MRL) in June 2018, which included the sale of all remaining iron ore at Yilgarn operations, fixed plant, equipment and non-process infrastructure. The asset sale transaction was completed in August 2018, with all assets transferred to the wholly owned MRL subsidiary Yilgarn Iron Pty Ltd (YIPL). Mining recommenced in September 2018. Pursuant to section 38(6) and (7) of the *Environmental Protection Act 1986*, Yilgarn Iron Pty Ltd was nominated as the person responsible for the Proposal on October 19th 2018, and contact details were updated accordingly.
982:M3.1	**Compliance Reporting**	The proponent shall maintain a Compliance Assessment Plan to the satisfaction of the CEO.	Maintain Compliance Assessment Plan (CAP)	Approved CAP	Overall	Ongoing	C	Cliffs submitted the Compliance Assessment Plan (CAP) to OEPA on 22 October 2014. OEPA approved the CAP on 2 December 2014 and determined that the CAP met the requirements of Conditions 3-1 and 3-2 of Statement 982 (OEPA Ref: 2014-0000970068). YIPL updated the CAP to reflect changes to the Proponent for MS982 and the location of publicly available reports outlined in Section 2.7 of the CAP. The update does not impact on any actions or requirements of the CAP that was approved by OEPA in 2014.
982:M3.2	**Compliance Reporting**	The proponent shall submit to the CEO the Compliance Assessment Plan required by condition 3-1 at least six months prior to the first compliance assessment report required by condition 3-6. The Compliance Assessment Plan shall indicate: (1) the frequency of compliance reporting; (2) the approach and timing of compliance assessments; (3) the retention of compliance assessments; (4) the method of reporting of potential non-compliances and corrective actions taken; and (5) the table of contents of compliance assessment reports.	Develop CAP in adherence to condition 3.2	Preparation and submission of CAP to CEO / Director General – DWER	Operation	6 months prior to first Compliance Assessment Report due, 30th October 2014.	CLD	Cliffs submitted the Compliance Assessment Plan (CAP) was submitted to OEPA on 22 October 2014. OEPA approved the CAP on 2 December 2014 and determined that the CAP met the requirements of Conditions 3-1 and 3-2 of Statement 982 (OEPA Ref: 2014-0000970068). YIPL updated the CAP to reflect changes to the Proponent for MS982 and the location of publicly available reports outlined in Section 2.7 of the CAP. The update does not impact on any actions or requirements of the CAP that was approved by OEPA in 2014.
982:M3.3	**Compliance Reporting**	The proponent shall assess compliance with conditions in accordance with the Compliance Assessment Plan required by condition 3-1.	CAP to be utilized when preparing Compliance Assessment Report	Annual CAR	Overall	Annually 30th April	C	This *2018 Annual Compliance Assessment Report* fulfils the requirement to assess compliance with the conditions of Statement 982 for the period 1 January 2018 to 31 December 2018.
982:M3.4	**Compliance Reporting**	The proponent shall retain reports of all compliance assessments described in the compliance assessment plan required by condition 3-1 and shall make those reports available when requested by the CEO.	Retain compliance assessments and provided to CEO upon request.	Records management	Overall	When requested by the CEO	C	Annual CARs are retained within and made available on MRL's electronic network and have been submitted to the CEO/Director General – Department of Water and Environmental Regulation (DWER) in accordance with the Compliance Assessment Plan.
982:M3.5	**Compliance Reporting**	The proponent shall advise the CEO of any potential non-compliance within seven days of that non-compliance being known.	Written notification	Submissions to the Director General – DWER	Overall	Within seven days of the potential non-compliance being known	NR	No potential non-compliances were recorded during the reporting period.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
982:M3.6	**Compliance Reporting**	The proponent shall submit to the CEO an annual Compliance Assessment Report by 30 April of each year, or as otherwise agreed by the CEO, addressing the period of the preceding calendar year The compliance assessment report shall: (1) be endorsed by the proponent's Managing Director / General Manager / Chief Executive Officer or a person delegated to sign on the Managing Director's / General Manager's / Chief Executive Officer's behalf; (2) address the proponent's compliance with each condition of this Statement; (3) describe corrective and preventative actions taken in the event of a non-compliance; and (4) indicate any proposed changes to the Compliance Assessment Plan required by condition 3-1.	Annual CAR will be endorsed, address compliance to statement 982, if necessary list corrective and preventive actions of non-compliance and changes to CAP	Annual CAR	Overall	Annually 30th April	C	This 2018 CAR is the fifth to be submitted as required by Ministerial Statement 982 and covers the period 1 January 2018 to 31 December 2018 being the previous full calendar year. This CAR is endorsed by MRL's General Manager of Technical Services, Mr Tim Berryman. YIPL was compliant with all conditions of MS 982 and as such there are no corrective or preventive actions to report. All YIPL's CARs will be made available to the public through publication on the MRL's website at http://www.mineralresources.com.au YIPL updated the CAP to reflect changes to the Proponent for MS982 and the location of publicly available reports outlined in Section 2.7 of the CAP. The update does not impact on any actions or requirements of the CAP that was approved by OEPA in 2014.
982:M4.1	**Public Availability of Plans and Reports**	Subject to condition 4-2, within a reasonable time period approved by the CEO of the issue of this Statement and for the remainder of the life of the proposal, the proponent shall make publicly available, in a manner approved by the CEO, all environmental plans and reports required under this Statement.	Annual CAR to be made publically available via Cliffs' website.	http://www.mineralresources.com.au	Overall	Ongoing	C	All YIPL's CARs and environmental management plans required under this statement will be made available to the public through prompt publication on the MRL website at http://www.mineralresources.com.au
982:M4.2	**Public Availability of Plans and Reports**	If any parts of the plans or reports referred to in condition 4-1 contains particulars of: (1) a secret formula or process; or (2) confidential commercially sensitive information; the proponent may submit a request for approval from the CEO to not make those parts of the plans or reports publically available. In making such a request the proponent shall provide the CEO with an explanation and reasons why those parts of the plans or reports should not be made publically available.	Written notification requesting reports/plans not be made publicly available		Overall	Ongoing	NR	YIPL did not request for any plans or reports or any sections of plans or reports not to be made publically available during the reporting period.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
982:M5.1	**Environmental Management Plans**	The proponent shall implement the proposal in accordance with the following approved Environmental Management Plans until condition 6-1 and condition 9-1 have been complied with, or unless otherwise agreed by the CEO: (1) Koolyanobbing Expansion Project – Northern Tenements Transport Corridor (Haul Road) Environmental Management Plan (2010). (2) Koolyanobbing Iron Ore Project – Biodiversity Research and Management Plan (2009). (3) Koolyanobbing Iron Ore Project – Malleefowl Conservation Plan (2009). (4) Yilgarn Operations Land Clearing Management Plan (2011). (5) Yilgarn Operations Dust Management Plan (2011). (6) Yilgarn Operations Fire Management Plan (2011). (7) Yilgarn Operations Weed Management Plan (2011). (8) Mt Jackson J1 Proposed Flora and Vegetation Monitoring Program (2012).	Continue to implement current management plans until conditions 6-1 and 9-1 have been complied with.	http://www.mineralresources.com.au	Operation	Until condition 6-1 and 9-1 are complied with unless otherwise agreed by the CEO	C	The *Yilgarn Operations Flora and Vegetation Management Plan* June 2016 (Revision G) was approved by the OEPA on 22 September 2016 (OEPA Ref: 16-030655). The *Yilgarn Operations Fauna Management Plan* June 2016 (Revision G) was approved by OEPA on 22 September 2016 (OEPA Ref: 16-030656).
982:M6.1	**Flora and Vegetation Management Plan**	The proponent shall ensure that the implementation of the proposal is carried out in a manner that minimises the direct and indirect impacts to conservation significant flora and vegetation through implementation of the Flora and Vegetation Management Plan required by conditions 6-2 and 6-3.	Implement the *Yilgarn Operations Flora and Vegetation Management Plan*	Monitoring reports *Yilgarn Operations Windarling Range 2018 Annual* Tetratheca paynterae *Monitoring,* (Revision B) (See Attachment 8 *2018 Annual Tetratheca paynterae Monitoring Report*) *Yilgarn Operations 2018 Annual Ricinocarpos brevis Monitoring at Windarling* (Revision 3) (See Attachment 9 2018 *Annual Ricinocarpos brevis Monitoring Report*) *Windarling 2018 W1 and W2 Flora Monitoring* (Revision 0) (See Attachment 10 *2018 W1 and W2 Flora Monitoring Report*) *Yilgarn Operations 2018 Mt Jackson Report on J1 Biodiversity Monitoring* (Revision 0) (See Attachment 11 *2018 J1 Biodiversity Monitoring Report*) *Yilgarn Operations 2018 Assessment of Fringing Vegetation at Lake K* (Revision 1) (See Attachment 12 2018 *Lake K Vegetation Monitoring Report*)	Operation	Ongoing from 24th September 2015	C	Completion and submission of flora and vegetation monitoring reports as attachments to this CAR demonstrates implementation of the Flora and Vegetation Management Plan required by conditions 6-2 and 6-3. Monitoring results confirm minimal direct and indirect impacts to conservation significant flora and vegetation as a result of implementation of the proposal.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
				Yilgarn Operations Koolyanobbing Report on Transport Corridor Flora Monitoring 2018 (Revision 0) (See Attachment 13 *Haul Road Vegetation Monitoring Report*)				
982:M6.2	**Flora and Vegetation Management Plan**	Within 12 months of the date of this Statement, or as otherwise agreed by the CEO, the proponent shall submit to the CEO a Flora and Vegetation Management Plan for the Yilgarn Operations, to the requirements of the CEO, in consultation with Parks and Wildlife.	Develop a Flora and Vegetation Management Plan in consultation with Parks and Wildlife and submit to the CEO	Submission of Flora and Vegetation Management Plan in accordance with Conditions 6 of MS 982	Operation	By 24th September 2015	C	The *Yilgarn Operations Flora and Vegetation Management Plan* (Revision G) was submitted to DPaW and OEPA on 29 April 2015. OEPA approval of the Plan was granted 22 September 2016 (OEPA Ref: 16-030655).
982:M6.3	**Flora and Vegetation Management Plan**	The Flora and Vegetation Management Plan shall include: (1) the management actions, targets and criteria to be applied to avoid and/or minimise the environmental impacts to conservation significant flora and vegetation from processes including, but not limited to, land clearing, changes in surface water flows, introduced flora (weeds), dust, fire, saline water and introduced fauna which may result from implementation of the proposal; and (2) monitoring to measure the performance of the management actions against the targets and criteria identified in the Flora and Vegetation Management Plan.	Develop Flora and Vegetation Management Plan in adherence to condition 6.3	Approved Flora and Vegetation Management Plan	Overall	Ongoing from 24th September 2015	C	The *Yilgarn Operations Flora and Vegetation Management Plan* (Revision G) was submitted to DPaW and OEPA on 29 April 2015. OEPA approval of the Plan was granted 22 September 2016 (OEPA Ref: 16-030655).
982:M6.4	**Flora and Vegetation Management Plan**	The proponent shall implement the approved Flora and Vegetation Management Plan required by condition 6-2, and continue implementation until otherwise agreed by the CEO, on advice of Parks and Wildlife.	Implement the Flora and Vegetation Management Plan	Monitoring reports as per Condition M6.1	Overall	Ongoing	C	The *Yilgarn Operations Flora and Vegetation Management Plan* (Revision G) was submitted to DPaW and OEPA on 29 April 2015. OEPA approval of the Plan was granted 22 September 2016 (OEPA Ref: 16-030655). YIPL continues to implement the Plan.
982:M6.5	**Flora and Vegetation Management Plan**	In the event that monitoring required by condition 6-3 indicates a decline in the health or abundance of conservation significant flora and/or vegetation outside areas to be cleared the proponent shall: (1) report such findings to the CEO within 21 days of the decline being identified; (2) provide information which allows determination of the cause of the decline; (3) submit actions to be undertaken to remediate the decline to the CEO within 21 days of the determination being made by the CEO if the decline is determined by the CEO to be a result of activities undertaken in implementing the proposal; and	Written correspondence to the CEO Consultation with DPaW	Notifications to OEPA	Overall	Within 21 days of decline being identified	C	In April 2017, Cliffs notified DWER of a decline in health of the Priority Flora taxa *Stenanthemum newbeyi*, and trigger criteria being met for the Rare Flora taxa *Tetratheca paynterae* subsp. *paynterae*. DWER were also notified of trigger criteria being met for the Rare Flora taxa *Ricinocarpos brevis* in August 2017. In response to the April 2017 notification, DWER requested monitoring reports be reviewed by an independent peer reviewer to determine if the conclusions in Cliffs' monitoring reports were supported or if further monitoring was required in

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
		(4) implement the actions to remediate the decline of conservation significant flora and vegetation upon approval of the CEO, on advice of Parks and Wildlife, and shall continue until such time as the CEO, on advice of Parks and Wildlife, determines that the remedial actions may cease.						order to determine the cause of the declines. With DWER's endorsement, Cliffs engaged Dr Eddie van Ettan of Edith Cowan University to conduct the peer review. He recommended that the trigger criteria be reviewed and the corresponding letter from DWER, dated 8th November 2017, supported this view (DWER Ref: DWERDA-010449). In March 2018, Cliffs sent the proposed amended *Yilgarn Operations Flora and Vegetation Management Plan* to DWER, which included the recommended changes to the trigger criteria as supported by the peer review and DWER. DWER responded and requested Cliffs undertake reporting consistent with Condition 3, MS 982, while they sought advice. Cliffs ceased mining in the second quarter of 2018 and no further updates or advice was received from DWER in relation to the proposed changes during this time. YIPL believes it has been adequately demonstrated that these trigger events do not indicate a correlation between mining operations and ongoing decline in numbers rare flora. YIPL will continue to engage with DWER to implement the revised Flora and Vegetation Management Plan developed by Cliffs and supported by the peer review and DWER in 2017.
982:M6.6	**Flora and Vegetation Management Plan**	Revisions to the Flora and Vegetation Management Plan may be approved by the CEO on the advice of Parks and Wildlife.	If necessary provide revision of management plan to CEO for approval	The YIPL formatted *Yilgarn Operations Flora and Vegetation Management Plan* is available on the MRL website www.mineralresources.com.au	Overall	Ongoing	NR	The *Yilgarn Operations Flora and Vegetation Management Plan* (Revision G) was approved by the OEPA on 22 September 2016 (OEPA Ref: 16-030655). YIPL continues to implement the approved Flora and Vegetation Management Plan. In 2019, minor updates were made to the Plan for the purpose of meeting Condition 4.1 (public availability of plans and reports) and providing up to date project information. This included making changes to: the document format (converted to MRL format so the document could be uploaded to MRL's website); the Proponent; relevant legislation and government department names (where applicable); YIPL's current operating areas (relevant to MS982); titles of persons responsible for management actions; scientific names and conservation status of conservation significant species listed in Attachment 1 (where applicable); and YIPL internal document numbers. No material changes were made to the management plan during the 2018 reporting period. YIPL will continue to engage with DWER to implement a revised *Yilgarn Operations Flora and Vegetation Management Plan* that reflects recommendations provided by Dr Eddie van Ettan and DWER in 2017 in regards to trigger criteria for conservation significant flora.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
982:M6.7	**Flora and Vegetation Management Plan**	The proponent shall implement approved revisions of the Flora and Vegetation Management Plan required by condition 6-6.	Implement approved Flora and Vegetation Management Plan	The YIPL formatted *Yilgarn Operations Flora and Vegetation Management Plan* is available on the MRL website www.mineralresources.com.au	Overall	Ongoing	NR	The *Yilgarn Operations Flora and Vegetation Management Plan* (Revision G) was approved by the OEPA on 22 September 2016 (OEPA Ref: 16-030655). The *Yilgarn Operations Flora and Vegetation Management Plan* (Revision G) was submitted to DPaW and OEPA on 29 April 2015. OEPA approval of the Plan was granted 22 September 2016 (OEPA Ref: 16-030655). YIPL continues to implement the approved Flora and Vegetation Management Plan. In 2019, minor updates were made to the Plan for the purpose of meeting Condition 4.1 (public availability of plans and reports) and providing up to date project information. This included making changes to: the document format (converted to MRL format so the document could be uploaded to MRL's website); the Proponent; applicable legislation and government department names; YIPL's current operating areas (relevant to MS982); titles of persons responsible for management actions; scientific names and conservation status of conservation significant species listed in Attachment 1 (where applicable); and YIPL internal document numbers. No material changes were made to the management plan. YIPL will continue to engage with DWER to implement a revised *Yilgarn Operations Flora and Vegetation Management Plan* that reflects recommendations provided by Dr Eddie van Ettan and DWER in 2017 in regards to trigger criteria for conservation significant flora.
982:M7.1	**Restricted Areas and Management of *Tetratheca paynterae* ssp. *paynterae* at the Windarling Range**	For the purposes of protecting the Rare Flora species Tetratheca paynterae ssp. paynterae, no ground disturbing activity shall occur in the area designated 'Area A', as identified in Figure 2 of Schedule 1.	There will be no ground disturbance of 'Area A' of Figure 2	Visual inspection, aerial photography and on ground photographic records.	Overall	Ongoing	C	No ground disturbing activity has occurred in 'Area A', as identified in Figure 2 of Schedule 1 of MS982 during the reporting period. The area is signposted with restricted access. See Attachment 14 Restricted areas Windarling Range
982:M7.2	**Restricted Areas and Management of *Tetratheca paynterae* ssp. *paynterae* at the Windarling Range**	For the purposes of protecting the Rare Flora species *Tetratheca paynterae* ssp. *paynterae* the proponent shall ensure that no ground disturbing activity shall occur in the area designated 'Area B' identified on Figure 2 of Schedule 1, unless the requirements of conditions 7-3, 7-4 and 7-5 have been complied with.	There will be no ground disturbance of 'Area B' of Figure 2 unless requirements of conditions 7-3, 7-4 and 7-5 have been complied with	Visual inspection, aerial photography and on ground photographic records.	Operation	Prior to ground disturbing activities	C	YIPL did not seek to undertake ground disturbing activity within 'Area B' during the reporting period. See Attachment 14 Restricted areas Windarling Range
982:M7.3	**Restricted Areas and Management of *Tetratheca paynterae* ssp. *paynterae* at the Windarling Range**	Where the proponent seeks to undertake ground disturbing activity within 'Area B', the proponent shall prepare a *Tetratheca paynterae* ssp. paynterae Research and Management Plan and a *Tetratheca paynterae* ssp. *paynterae* Recovery Plan to the requirements of the	Develop *Tetratheca paynterae* ssp. *paynterae* Research and Management Plan and a Tetratheca paynterae ssp. paynterae Recovery Plan to the	Approved *Tetratheca paynterae* subsp. *paynterae* Research and Management Plan	Operation	Prior to ground disturbing activities	NR	The *Tetratheca paynterae* Research and Management Plan was prepared in draft form and submitted to the DER in 2006 and approved as an Interim Recovery Plan on 16 June 2006. However, there is no obligation to finalise and implement the plan provided that mining access to 'Area B' is not

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
		Minister for Environment on the advice of Parks and Wildlife.	requirements of the Minister for Environment on the advice of Parks and Wildlife					sought. YIPL does not propose to finalise the *Tetratheca paynterae* Research and Management Plan for implementation unless it is required for access to 'Area B'. YIPL did not seek to undertake ground disturbing activity within 'Area B' during the reporting period.
982:M7.4	**Restricted Areas and Management of *Tetratheca paynterae* ssp. *paynterae* at the Windarling Range**	The *Tetratheca paynterae* ssp. *paynterae* Research and Management Plan required by condition 7-3 shall include: (1) monitoring of the numbers of *Tetratheca paynterae* ssp. *paynterae* individuals, their health, viability of the population, and reproductive success within 'Area A' and 'Area B'; (2) research into the ecology and potential translocation of *Tetratheca paynterae* ssp. *paynterae* with a focus on the specific natural habitat requirements of the species; (3) research into the pollination vector(s) of *Tetratheca paynterae* ssp. *Paynterae* to identify the vector(s) and the specific ecological requirements; (4) management measures to protect the health, viability, and reproductive success of the *Tetratheca paynterae* ssp. *paynterae* population; and (5) measures to support the secure conservation tenure for the remaining population of *Tetratheca paynterae* ssp. *paynterae*.	Develop *Tetratheca paynterae* ssp. *paynterae* Research and Management Plan in adherence to condition 7.4	Approved *Tetratheca paynterae* ssp. *paynterae* Research and Management Plan	Operation	Prior to ground disturbing activities	NR	YIPL did not seek to undertake ground disturbing activity within 'Area B' during the reporting period.
982:M7.5	**Restricted Areas and Management of *Tetratheca paynterae* ssp. *paynterae* at the Windarling Range**	The proponent shall implement the approved *Tetratheca paynterae* ssp. *paynterae* Research and Management Plan and *Tetratheca paynterae* ssp. *paynterae* Recovery Plan required by condition 7-3, until advised by the Minister for Environment that implementation may cease.	Implement *Tetratheca paynterae* ssp. *paynterae* Research and Management Plan	Approved *Tetratheca paynterae* ssp. *paynterae* Research and Management Plan	Operation	Prior to ground disturbing activities	NR	YIPL did not seek to undertake ground disturbing activity within 'Area B' during the reporting period.
982:M7.6	**Restricted Areas and Management of *Tetratheca paynterae* ssp. *paynterae* at the Windarling Range**	Ground disturbing activity within the area designated 'Area B' may only occur when the Minister for Environment, on the advice of Parks and Wildlife, is satisfied and provides written advice stating that it has been demonstrated that ground disturbing activity in whole or part of the area designated 'Area B', will not result in a reduction in the viability of the population of *Tetratheca paynterae* ssp. *paynterae*, and may proceed.	Ground disturbance not to occur in 'Area B' until approval from the Minister for the Environment	Approval from the Minister for the Environment	Operation	Prior to ground disturbing activities	NR	YIPL did not seek to undertake ground disturbing activity within 'Area B' during the reporting period.
982:M7.7	**Restricted Areas and Management of *Tetratheca paynterae* ssp. *paynterae* at the Windarling Range**	The proponent shall report the results and outcomes of the *Tetratheca paynterae* ssp. *paynterae* Research and Management Plan and *Tetratheca paynterae* ssp. *paynterae* Recovery Plan annually to Parks and Wildlife.	Annual *Tetratheca paynterae* Research Progress Report		Operation	Annually once ground disturbance occurs	NR	YIPL did not seek to undertake ground disturbing activity within 'Area B' during the reporting period.
982:M8.1	**Mitigation of impacts to *Calytrix viscida* for the Deception Deposit**	Prior to impacting the Priority Flora species *Calytrix viscida* at the Deception Deposit, the proponent shall collect seeds and plant material of the Calytrix viscida that will be impacted. The seeds and plant material will be stored in a facility that is capable of maintaining their viability for use during rehabilitation works at the Deception Deposit.	Seed to be collected and stored periodically	A quantity of seed is adequately stored onsite. Plant material has been collected and is being propagated at a specialist plant nursery.	Overall	Ongoing	C	*Calytrix viscida* seed has been collected and is stored in accordance with FAO/IPGRI 2014 '*Genebank Standards'* (Food and Agriculture Organisation of the United Nations / International Plant Genetic Resources Institute: Rome (2014)). Seed was collected from the plant once the seed had matured and was dried in a desiccator in a temperature controlled air-conditioned room. This maintains drying conditions at 20°C and 10-15% relative humidity. Seeds have been sealed in an airtight container and are stored in a chest freezer at minus 20°C which will ensure their ongoing viability for use during rehabilitation works at the Deception Deposit.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
								Plant material "cuttings" were collected from approximately thirty individual plants of *Calytrix viscida* prior to ground disturbance activity occurring in late July 2017. The "cuttings" were immediately transported to a plant nursery, "Natural Areas" based in Whiteman, Western Australia which specialises in plant propagation. The nursery is accredited under the Nursery Industry Accreditation Scheme Australia (NIASA), which stipulates high standards of nursery hygiene. The nursery is subjected to annual auditing and has maintained accreditation since 2008. The nursery is also affiliated and active in the International Plant Propagation Society (IPPS) Society and the Australian Network for Plant Conservation Inc. (ANPC). During the 2017 reporting period one individual was alive. Given the relatively limited success of the cuttings, Cliffs proposed to not collect any further plant material from the *Calytrix viscida* population.
982:M8.2	**Mitigation of impacts to *Calytrix viscida* for the Deception Deposit**	Where the *Calytrix viscida* is impacted by mining at the Deception Deposit, the proponent shall undertake a targeted regional flora survey to the satisfaction of the CEO to improve knowledge of the presence and abundance of *Calytrix viscida* outside of the approved disturbance area for the Deception Deposit. The survey shall be conducted in accordance with Environmental Protection Authority Guidance Statement 51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (June 2004) or its revisions.	Conduct regional flora survey in adherence to condition 8.2 if impacts to *Calytrix viscida* from mining occur at the Deception Deposit.	Attachment 15 Deception Disturbance	Overall	If *Calytrix viscida* is impacted by mining	NR	The *Calytrix viscida* population at Deception was avoided during mine planning and development of the Deception pit and associated infrastructure. As a result there no has been no impact to this population from mining. YIPL utilises a stringent site disturbance permitting process which involves, initial application (with supporting documentation), review of the application, onsite inspection, operator training and post disturbance verification of disturbed areas. The map accompanying the site disturbance application and the post disturbance survey verification for the Deception Pit and ROM are included with this report. It can be seen from these that the *Calytrix viscida* population at Deception was not directly impacted by these activities and no further disturbance has occurred in the area since that time. See Attachment 15 Deception Disturbance. Individual plant monitoring of a subset of *Calytrix viscida* individuals was undertaken in July 2017 (prior to commencement of mining) and was repeated in 2018.
982:M8.3	**Mitigation of impacts to *Calytrix viscida* for the Deception Deposit**	Unless otherwise agreed with the CEO, the proponent shall report to the CEO on the findings of the targeted regional flora survey required under condition 8-2 within 24 months of impact to *Calytrix viscida*.			Overall	Within 24 months of impact	NR	The *Calytrix viscida* population at Deception was avoided during mine planning and development of the Deception pit and associated infrastructure. As a result, there no has been no impact to this population from mining.
982:M9.1	**Fauna Management Plan**	The proponent shall ensure that the implementation of the proposal is carried out in a manner that minimises the direct and indirect impacts to conservation significant fauna through implementation of the Fauna Management Plan required by conditions 9-2 and 9-3.	Implement Fauna Management Plan	Annual Report and Fauna Management Plan Objective Assessment Table Malleefowl Nest Mound Annual Monitoring Mt Jackson	Overall	Ongoing	C	The *Yilgarn Operations Fauna Management Plan* June 2016 (Revision G) was approved by the OEPA on 22 September 2016 (OEPA Ref: 16-030656). YIPL continues to implement the approved Fauna Management Plan. In 2019, minor updates were made to the Plan for the purpose of meeting

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
				(See Attachment 16 2018 *Annual Malleefowl Nest Mound Monitoring Report*)				Condition 4.1 (public availability of plans and reports) and providing up to date project information. This included making changes to: the document format (converted to MRL format so the document could be uploaded to MRL's website); the Proponent; applicable legislation and government department names; YIPL's current operating areas (relevant to MS982); titles of persons responsible for management actions; scientific names and conservation status of conservation significant species listed in Attachment 1 (where applicable); and YIPL internal document numbers. No material changes were made to the management plan. Management controls and completion and submission of the annual fauna monitoring report and the Fauna Management Plan demonstrates implementation of the Fauna Management Plan required by conditions 9-2 and 9-3. Routine (annual) monitoring of fauna is undertaken for *Leipoa ocellata* (Malleefowl). This monitoring program has corroborated the findings of earlier studies in relation to the impacts of mine activity on the Mt Jackson Malleefowl populations. The findings of the 2018 study were consistent with 2017 data and concluded there was no significant relationship between mound activity and the distance from the main sources of mine activity. Overall the number of active mounds is relatively stable with only small fluctuations in estimated population within the sample group. Mound activity has not fluctuated significantly in the years of the program which suggests a relatively stable population within the study area.
982:M9.2	**Fauna Management Plan**	Within 12 months of the date of this Statement, or as otherwise agreed by the CEO, the proponent shall submit to the CEO a Fauna Management Plan for the Yilgarn Operations to the requirements of the CEO, in consultation with Parks and Wildlife.	Develop a Fauna Management Plan in consultation with Parks and Wildlife and submit to the CEO	Submission of Environmental Management Plan in accordance with Condition 9 of MS 982	Operation	By 24 September 2015	C	Following consultation with DPaW, the *Yilgarn Operations Fauna Management Plan* June 2016 (Revision G) was submitted to OEPA in June 2016. OEPA approval of the Plan was granted 22 September 2016 (OEPA Ref: 16-030656). YIPL continues to implement the approved Fauna Management Plan. In 2019, minor updates were made to the Plan for the purpose of meeting Condition 4.1 (public availability of plans and reports) and providing up to date project information. This included making changes to: the document format (converted to MRL format so the document could be uploaded to MRL's website); the Proponent; applicable legislation and government department names; YIPL's current operating areas (relevant to MS982); titles of persons responsible for management actions; scientific names and conservation status of conservation significant species listed in Attachment 1 (where applicable);

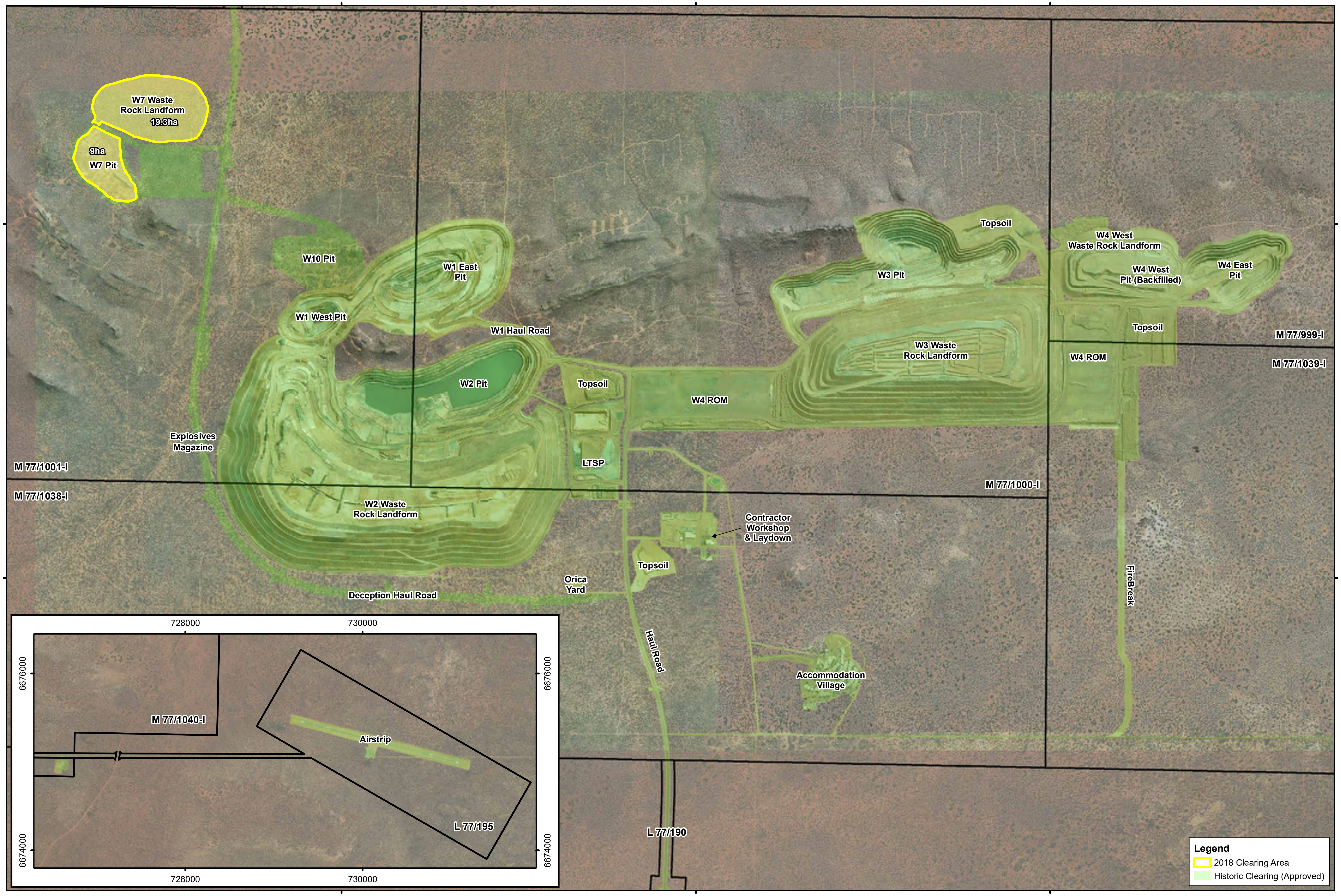
Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
								and YIPL internal document numbers. No material changes were made to the management plan.
982:M9.3	**Fauna Management Plan**	The Fauna Management Plan shall include: (1) the management actions, targets and/or criteria to be applied to avoid and/or minimise the environmental impacts to conservation significant fauna, including Malleefowl (*Leipoa ocellata*), from processes including, but not limited to, land clearing, changes in surface water flows, introduced flora (weeds), dust, fire, saline water and introduced fauna resulting from implementation of the proposal; and (2) monitoring to measure and report the performance of management actions against the targets and/or criteria identified in condition 9-3(1).	Develop Fauna Management Plan in adherence to condition 9.3	Submission of MS 982 Conditions 6 & 9 EMP	Overall	Ongoing from 24 September 2015	C	The *Yilgarn Operations Fauna Management Plan* includes management actions and controls that have been implemented by YIPL to avoid and/or minimise the environmental impacts to conservation significant fauna. Malleefowl monitoring has been conducted in accordance with the Plan with the results provided in the 2018 *Mt Jackson Malleefowl Nest Mound Annual Monitoring Report* (See Attachment 16).
982:M9.4	**Fauna Management Plan**	The proponent shall implement the Fauna Management Plan required by condition 9-2, and continue implementation unless otherwise agreed by the CEO, on the advice of Parks and Wildlife.	Implement the Fauna Management Plan		Overall	Ongoing	C	The *Yilgarn Operations Fauna Management Plan* June 2016 (Revision G) was approved by OEPA on 22 September 2016 (OEPA Ref: 16-030656). YIPL continues to implement the approved Fauna Management Plan. In 2019, minor updates were made to the Plan for the purpose of meeting Condition 4.1 (public availability of plans and reports) and providing up to date project information. This included making changes to: the document format (converted to MRL format so the document could be uploaded to MRL's website); the Proponent; applicable legislation and government department names; YIPL's current operating areas (relevant to MS982); titles of persons responsible for management actions; scientific names and conservation status of conservation significant species listed in Attachment 1 (where applicable); and YIPL internal document numbers. No material changes were made to the management plan.
982:M9.5	**Fauna Management Plan**	In the event that monitoring undertaken in accordance with condition 9-3 indicates a decline in the health or abundance of conservation significant fauna, including Malleefowl (*Leipoa ocellata*), populations within the proposal area: (1) report such findings to the CEO within 21 days of the decline being identified; (2) provide information which allows determination of the cause of the decline; (3) submit actions to be undertaken to remediate the decline to the CEO within 21 days of the determination being made by the CEO if the decline is determined by the CEO to be a result of activities undertaken in implementing the proposal; and (4) implement the actions to remediate the decline of conservation significant fauna upon approval of the CEO, on advice of Parks and Wildlife, and shall continue until such time as the CEO, on advice of Parks and Wildlife, determines that the remedial actions may cease.	Written correspondence to the CEO		Overall	Within 21 days of decline being identified	NR	There has been no decline in the health or abundance of Malleefowl populations in the proposal area during the reporting period. Therefore, there has been no requirement to notify DWER or implement remedial actions. (See Attachment 16 2018 *Mt Jackson Annual Malleefowl Nest Mound Monitoring Report*).

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
982:M9.6	**Fauna Management Plan**	Revisions to the Fauna Management Plan may be approved by the CEO on the advice of Parks and Wildlife.	If necessary provide revision of management plan to CEO for approval	Approved Fauna Management Plan	Overall	Ongoing	C	No material changes were made to the Fauna Management Plan during the reporting period. In 2019, minor updates were made to the Plan for the purpose of meeting Condition 4.1 (public availability of plans and reports) and providing up to date project information. This included making changes to: the document format (converted to MRL format so the document could be uploaded to MRL's website); the Proponent; applicable legislation and government department names; YIPL's current operating areas (relevant to MS982); titles of persons responsible for management actions; scientific names and conservation status of conservation significant species listed in Attachment 1 (where applicable); and YIPL internal document numbers. No material changes were made to the management plan. .
982:M9.7	**Fauna Management Plan**	The proponent shall implement approved revisions of the Fauna Management Plan required by condition 9-6.	Implement approved Fauna Management Plan	Annual CAR	Overall	Ongoing	C	No material changes were made to the Fauna Management Plan during the reporting period. In 2019, minor updates were made to the Plan for the purpose of meeting Condition 4.1 (public availability of plans and reports) and providing up to date project information. This included making changes to: the document format (converted to MRL format so the document could be uploaded to MRL's website); the Proponent; applicable legislation and government department names; YIPL's current operating areas (relevant to MS982); titles of persons responsible for management actions; scientific names and conservation status of conservation significant species listed in Attachment 1 (where applicable); and YIPL internal document numbers. No material changes were made to the management plan.
982:M10.1	**Residual Impacts and Risk Management Measures (Environmental Offsets)**	To offset the impact of mining at the Windarling Range W1 deposit on the landscape and geological features of the range and local area and related conservation values, within 12 months following the purchase of the former Ennuin Pastoral Lease by Parks and Wildlife, the proponent shall make a financial contribution of $50,000 AUD per year over a 5-year period (total $250,000 AUD) to Parks and Wildlife, to assist with the management of the former Ennuin Pastoral Lease.	Cliffs to make annual payments to DPaW	DPaW Invoice for 2017	Overall	Within 12 months of purchase	C	Cliffs' financial contribution to DPaW of $50,000 AUD annually for five years commenced in 2013 with the final payment being made in this reporting period in March 2017. This completed the payment of a total of $250,000AUD to Parks and Wildlife, to assist with the management of the former Ennuin Pastoral Lease.
982:M10.2	**Residual Impacts and Risk Management Measures (Environmental Offsets)**	To offset the impact of mining at the Windarling Range W4 East deposit on the Rare Flora species *Ricinocarpos brevis*, the proponent shall provide a minimum financial contribution of $640,000 AUD over a five year period for the purpose of undertaking works that seek to contribute to the scientific understanding of the long term recovery and protection of sustainable populations of *Ricinocarpos brevis* at the Windarling Range. The works will commence within 12 months following impact to *Ricinocarpos brevis* at the	Develop and implement research management plan in adherence to condition 10.2	Attachment 17 *Restoration Research Final Report: Ricinocarpos brevis 2013-2018* Attachment 18 Cliffs' ARC invoices 2016-2017	Overall	Within 12 months following impact to *Ricinocarpos brevis*	C	The *Kings Park and Botanic Garden, Restoration Research Plan,* Cliffs Asia Pacific Iron Ore Pty Ltd, *Yilgarn Operations – Windarling Range* was developed during 2012 and approved by OEPA mid-2013. The Plan has been continually implemented since this time with formal reporting annually.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
		Windarling Range W4 East Deposit. The works will be implemented in consultation with Parks and Wildlife and to the satisfaction of the CEO.						The five-year research period for BGPA concluded in 2017 with the final report issued in 2018 (see Attachment 17 *Restoration Research Final Report: Ricinocarpos brevis 2013-2018*). Botanic Garden and Parks Authority (BGPA) were paid $580,428.45 to complete the Restoration and Research Plan. An agreement was reached in 2016 for a number of elements of the Restoration Research Plan to be subsumed into an Australian Research Council (ARC) Project though the Industrial Transformation Training Centre for Mining Restoration (ARC Project ID: ICI150100041). Cliffs subsequently provided $110, 000 AUD in direct contributions to the ARC Project from 2016-2017. The sum total of these commitments well exceeds the minimum financial contribution of $640, 000 AUD required by this condition and concludes YIPL's obligations for this Environmental Offset.
982:M10.3	**Residual Impacts and Risk Management Measures (Environmental Offsets)**	To offset the impact of mining at the Windarling Range W4 East deposit on the Rare Flora species *Ricinocarpos brevis*, the proponent will provide a minimum financial contribution of $40,000 AUD for the translocation of a proportion of individuals of *Ricinocarpos brevis* that will be removed by mining of the Windarling Range W4 East Deposit. The number of individuals to be translocated will be subject to practicability considerations such as plant size and site accessibility. A translocation plan shall be developed and implemented by the proponent in consultation with Parks and Wildlife, and to the satisfaction of the CEO.	Develop and implement translocation plan in adherence to condition 10.3	Yilgarn Operations Windarling Range Proposal for Translocation of *Ricinocarpos brevis,* December 2012 (Revision 0) *Yilgarn Operations Windarling Range Ricinocarpos brevis Whole Plant Translocation Trial* May 2016 (Revision 0)	Overall	Ongoing	C	In December 2012 Cliffs submitted a proposal for translocation of *Ricinocarpos brevis* to OEPA which was approved for implementation in January 2013. Plan activities commenced in 2013 with more than 50 mature *R. brevis* plants removed from the W4 mining area. These were placed in planter bags and reticulated in preparation for translocation. In April 2015, 15 of the surviving plants were translocated to the W2 waste dump. Monitoring in July 2017 recorded a survival rate of 67% (10/15 individuals), with some individuals also flowering and fruiting. No further monitoring was proposed for this work however the results are valuable for informing ongoing rehabilitation and restoration works. Cliffs estimated that through direct financial spend to its earthmoving contractor, purchase of consumables and in kind support including environmental personnel time (particularly for supervision of contractors and plant watering) a financial contribution well in excess of the minimum $40, 000 AUD was made to this translation program.
982:M11.1	**Mine Closure and Rehabilitation**	The proponent shall ensure that the mining operations are closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed post-mining outcomes and land uses, without unacceptable liability to the State of Western Australia through implementation of a Mine Closure Plan required by condition 11-2.	Closure, decommissioning and rehabilitation to be undertaken in accordance with Mine Closure Plan	Rehabilitation and monitoring reports	Decommissioning and Overall	Ongoing	C	Progressive rehabilitation and mine closure activities continued during 2018 in accordance with the previously approved Windarling and Mt Jackson Mine Closure Plans. The Y*ilgarn Operations Mine Closure Plan,* currently under review, once approved will be formally implemented. Rehabilitation for the reporting period were focused on activities such as the battering down of waste dumps and movement of topsoil. Analysis of the data collected during the 2018 rehabilitation monitoring program has generally demonstrated very good progress toward achievement of closure criteria across the project.

Audit Code	Subject	Requirement	How	Evidence	Phase	Timeframe	Status	Further Information
								Most of the monitored sites also demonstrated improvement in the closure criteria when compared to previous results. See Attachment 19 *2018 Rehabilitation Monitoring Report – Koolyanobbing, Mt Jackson and Windarling* for the results of rehabilitation monitoring and comparison to reference sites and previously collected data.
982:M11.2	**Mine Closure and Rehabilitation**	Within 12 months of the date of this Statement, or as otherwise agreed by the CEO, the proponent shall submit a Mine Closure Plan for the Yilgarn Operations to the requirements of the CEO, in consultation with Parks and Wildlife and the DMP. The Mine Closure Plan shall: (1) be prepared in accordance with the *Guidelines for Preparing Mine Closure Plans, June 2011* (Department of Mines and Petroleum and Environmental Protection Authority) or its revisions; (2) detail the methods to be used for progressive rehabilitation of disturbed areas with vegetation composed of native species of local provenance such that the percentage cover of living vegetation is comparable to natural vegetation surrounding the proposal; (3) detail the methods, including monitoring and recording programs for feral animal populations and the health and condition of conservation significant flora and vegetation, and conservation significant fauna species, including Malleefowl (*Leipoa ocellata*), which will be used to ensure that surface water within pit lakes does not result in an increase in introduced fauna to a level that may have a measurable impact on conservation significant flora and vegetation or conservation significant fauna species; (4) detail the methods to ensure the effectiveness of backfilling in preventing the presence of permanent surface water in those pits approved for backfilling, following the completion of backfilling, unless otherwise approved by the CEO, in consultation with Parks and Wildlife; and (5) examine opportunities for backfilling the Windarling W3/5 pit voids above the watertable, to ensure that impacts on important conservation values and any long term liabilities for future management are minimised.	Develop Mine Closure Plan in adherence to condition 11.2	*Yilgarn Operations Mine Closure Plan* (submitted by Cliffs in April 2015 and YIPL in late 2018)	Overall	By 24 September 2015	C	Cliffs originally submitted the Y*ilgarn Operations Mine Closure Plan (Revision 0)* April 2015 to DMIRS (formerly Department of Mines of Petroleum) in April 2015. Since the initial submission Cliffs undertook considerable consultation with regulatory agencies and other stakeholders. Formal regulatory approval of the *Yilgarn Operations Mine Closure Plan* had not been received prior to Cliffs ceasing mining operations at Koolyanobbing. Following the takeover of Koolyanobbing operations, YIPL subsequently submitted a revised copy of the Plan to DMIRS and DWER – EPA Services in late 2018 (at the request of DMIRS) and is currently awaiting comments.
982:M11.3	**Mine Closure and Rehabilitation**	The proponent shall implement the approved Mine Closure Plan required by condition 11-2 and continue implementation until otherwise agreed by the CEO, on the advice of Parks and Wildlife and the DMP.	Implement the approved Mine Closure Plan	Annual CAR	Overall	Ongoing	C	Progressive rehabilitation and mine closure activities continued during 2018 in accordance with the previously approved Windarling Mine Closure Plan and Mt Jackson Mine Closure Plan and will continue as scheduled until the Y*ilgarn Operations Mine Closure Plan* submitted by YIPL in late 2018 is formally endorsed by DMIRS and DWER – EPA Services.
982:M11.4	**Mine Closure and Rehabilitation**	Revisions to the Mine Closure Plan may be approved by the CEO on the advice of Parks and Wildlife and the DMP.	If necessary provide revision of closure plan to CEO for approval	Approved Mine Closure Plan	Overall	Ongoing	N/A	No revisions to the Mine Closure Plan were approved by the CEO/Director General during the reporting period.
982:M11.5	**Mine Closure and Rehabilitation**	The proponent shall implement approved revisions of the Mine Closure Plan required by condition 11-4.	Implement approved Mine Closure Plan		Overall	Ongoing	N/A	No revisions to the Mine Closure Plan were approved by the CEO/Director General during the reporting period.

Attachment 3 – Land Clearing Footprint at Windarling Operations



Notes:

0 200 400m

Scale: 1:20,000

GDA 1994 MGA Zone 50

Author: N. Smith

Date: Mar 2019 | Rev: A | A3

CADRef: a2645_MRF_Windarling_002

Drawn: CAD Resources ~ www.cadresources.com.au

Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

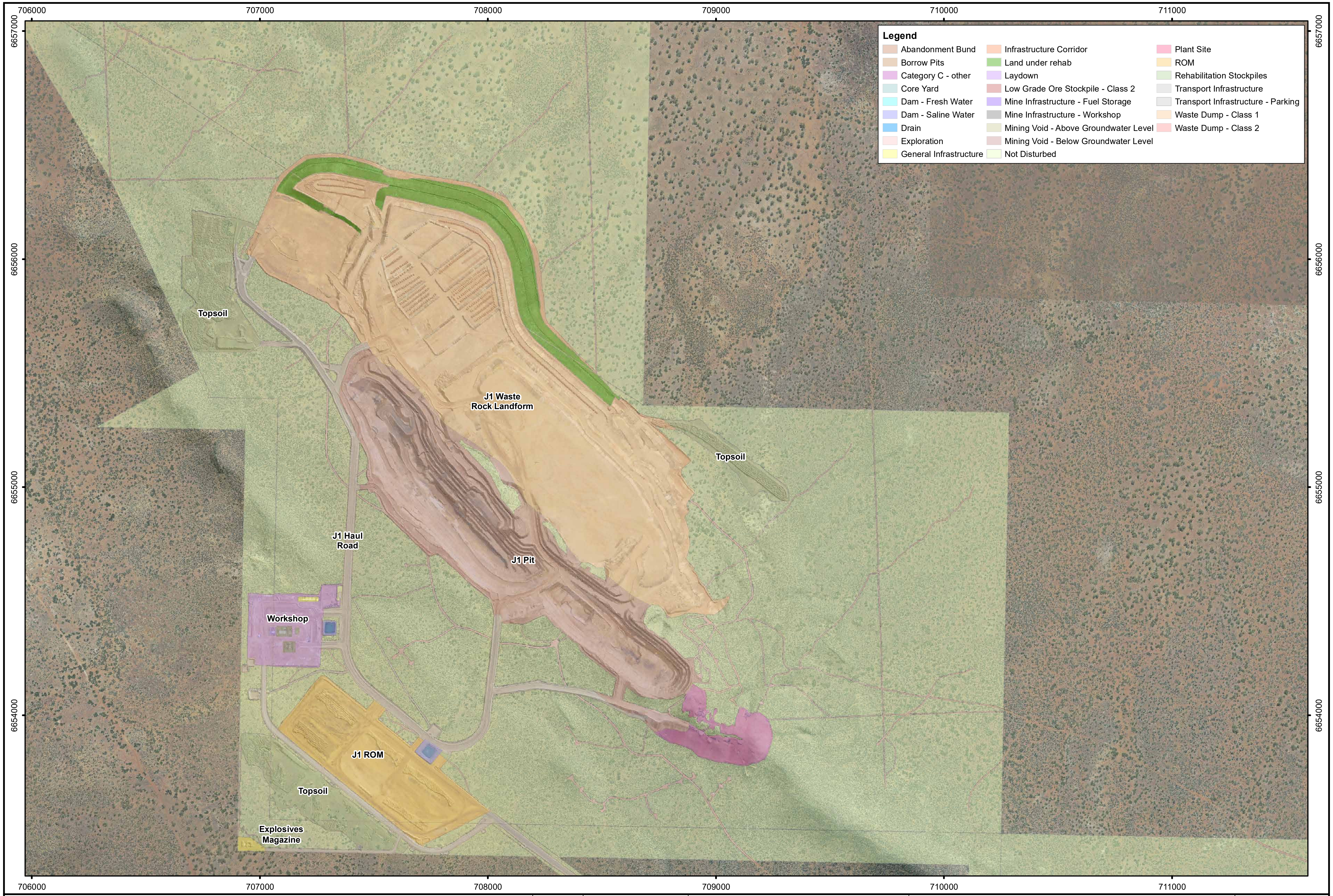
Yilgarn Operations

Windarling Range Mine Operations

2018 Clearing

Figure: 1

Attachment 4 – Land Clearing Footprint at Mt Jackson J1 Operations



Notes:

0 150 300 m

Scale: 1:15,000
GDA 1994 MGA Zone 50

Author: N. Smith

Date: Mar 2019 | Rev: A | A3

MINERAL RESOURCES

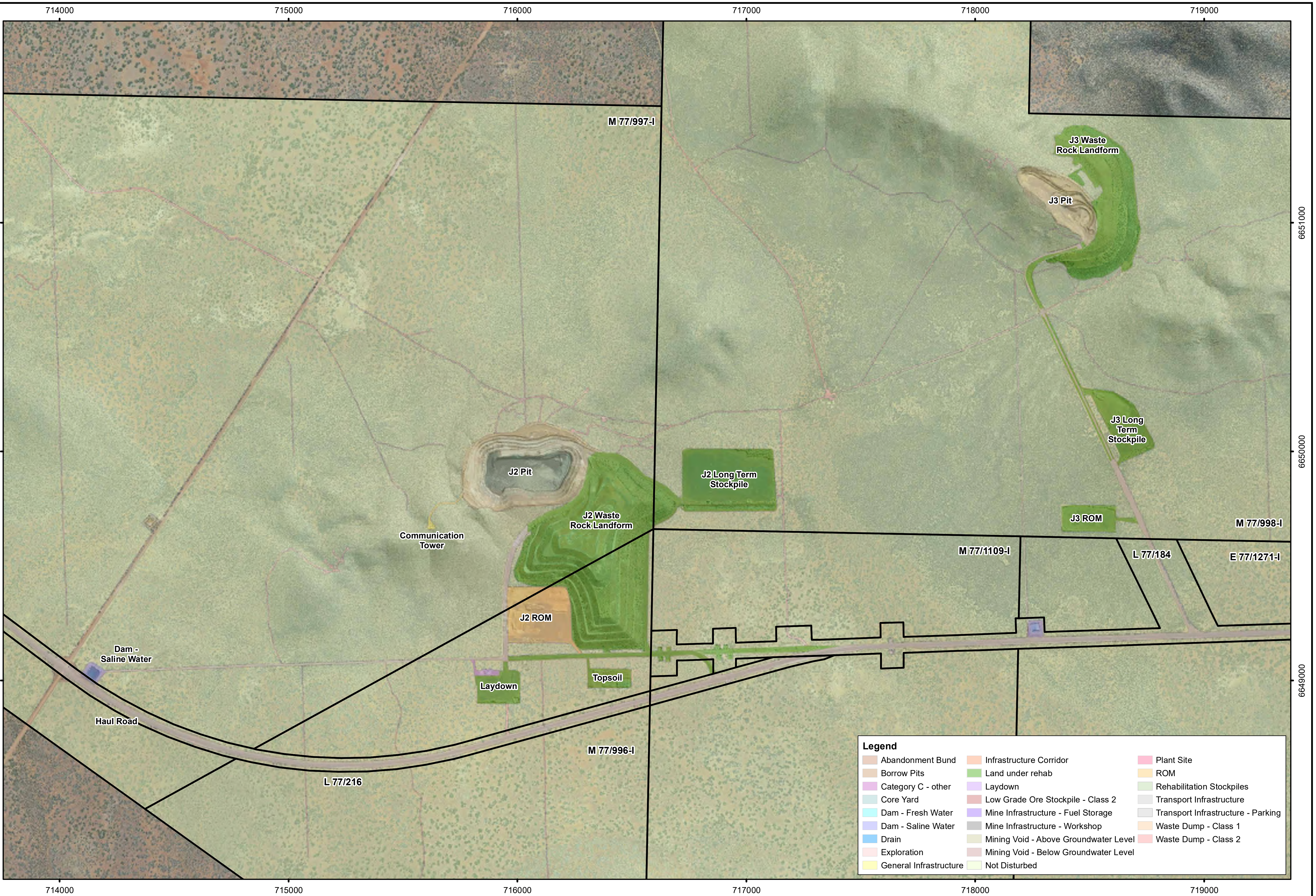
CADRef: a2645_MRF_MtJacksonJ1_001

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

Yilgarn Operations
Mt Jackson Range - J1
2019 MRF Category Areas

Figure: 1

Attachment 5 – Land Clearing Footprint Mt Jackson Operations J2/J3 Operations



Notes:

0 150 300 m

Scale: 1:15,000

GDA 1994 MGA Zone 50

Author: N. Smith

Date: Mar 2019 | Rev: A | A3

CADRef: a2645_MRF_MtJackson_001

Drawn: CAD Resources ~ www.cadresources.com.au

Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

Yilgarn Operations

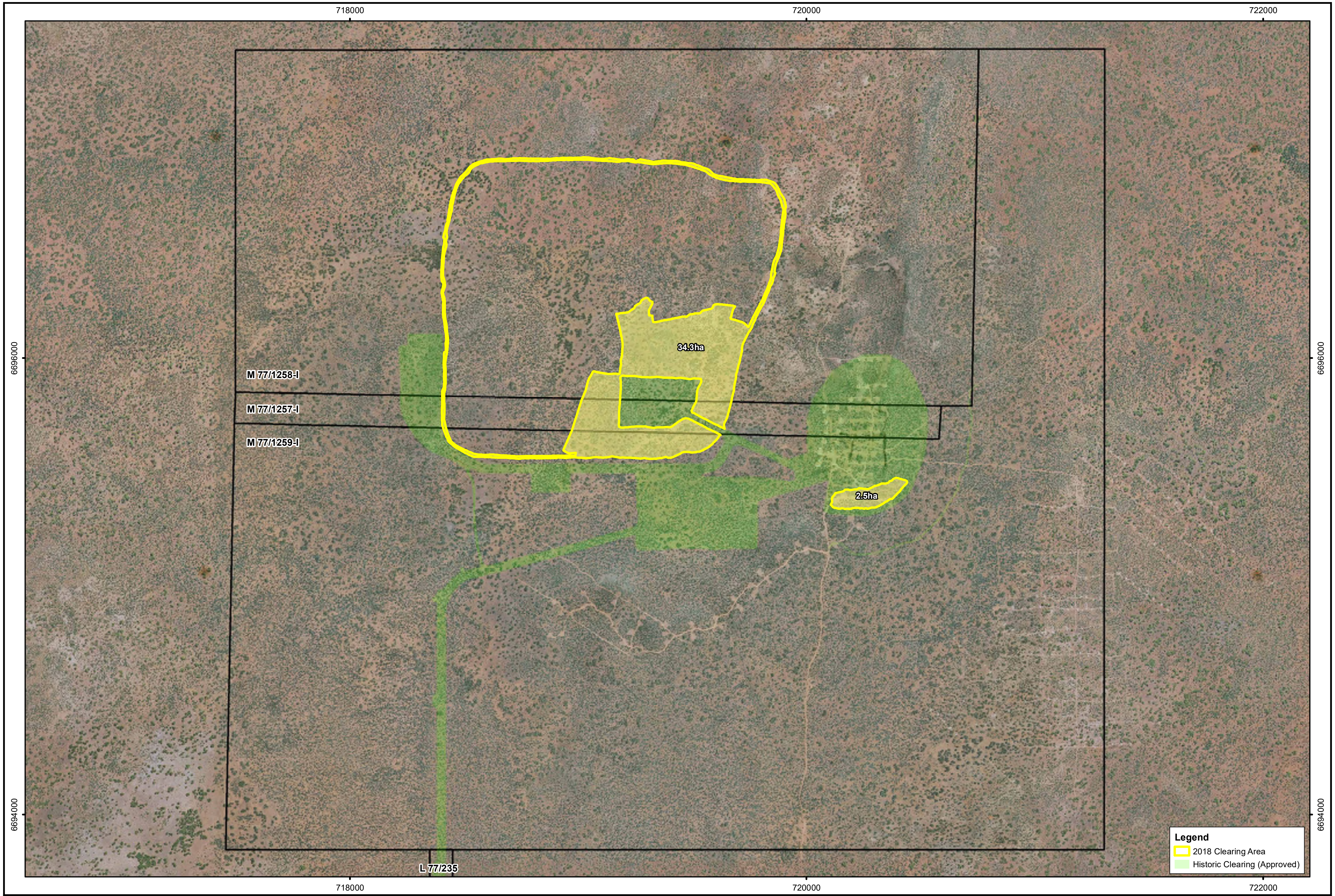
Mt Jackson Range - J2/J3

2019 MRF Category Areas

Figure:

1

Attachment 6 – Land Clearing Footprint at Deception Deposit



Notes:

N

0 150 300m

Scale: 1:15,000

GDA 1994 MGA Zone 50

Author: N. Smith

Date: Mar 2019 | Rev: A | A3

CADRef: a2645_MRF_Deception_002

Drawn: CAD Resources ~ www.cadresources.com.au

Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

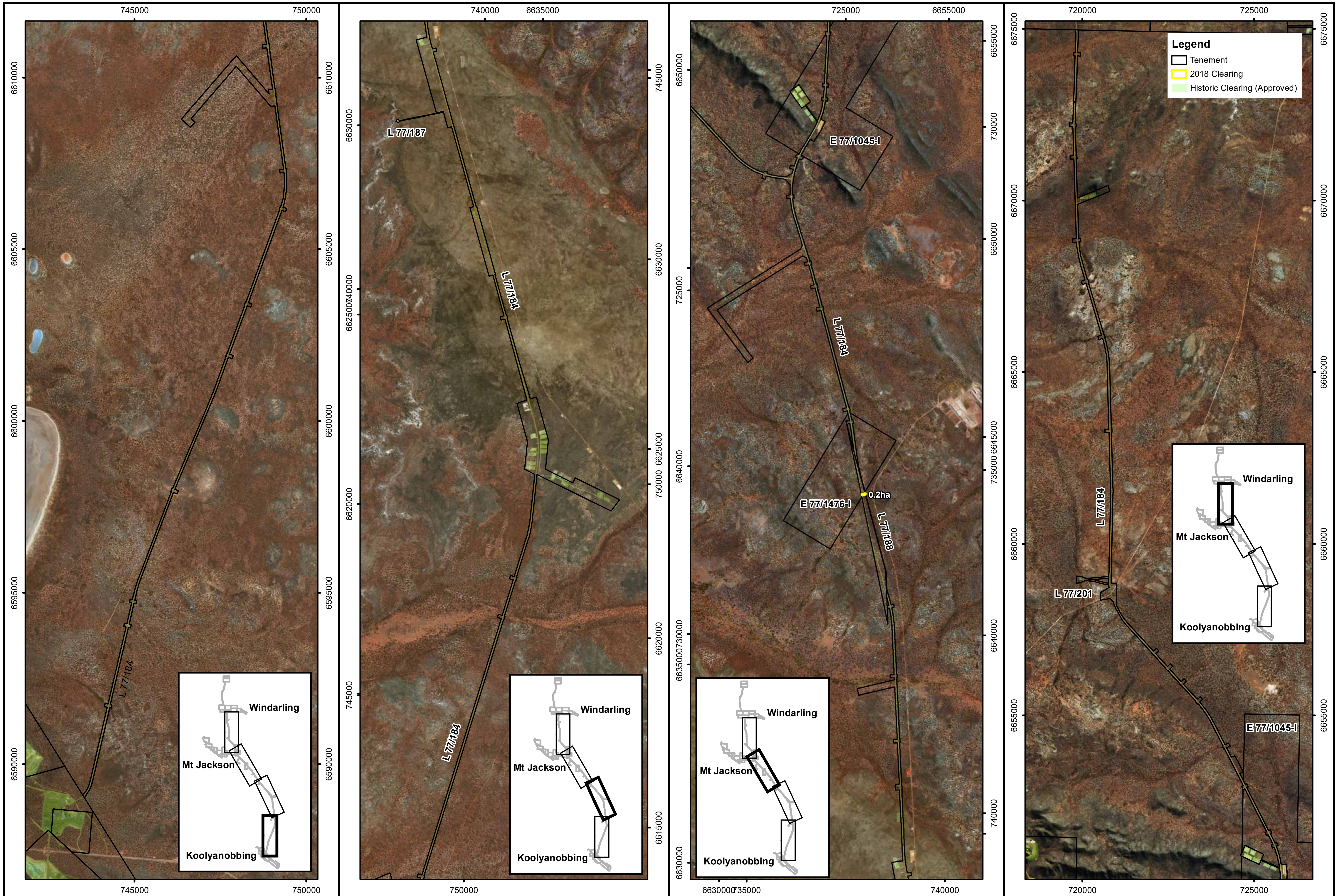
Yilgarn Operations

Deception Mine Operations

2018 Clearing

Figure: **1**

Attachment 7 – Clearing Footprint for Yilgarn Operations Haul Roads



Imager: ESRI, DgitalGlobe (2016)

0 1 2km
Scale: 1:100,000
GDA 1994 MGA Zone 50

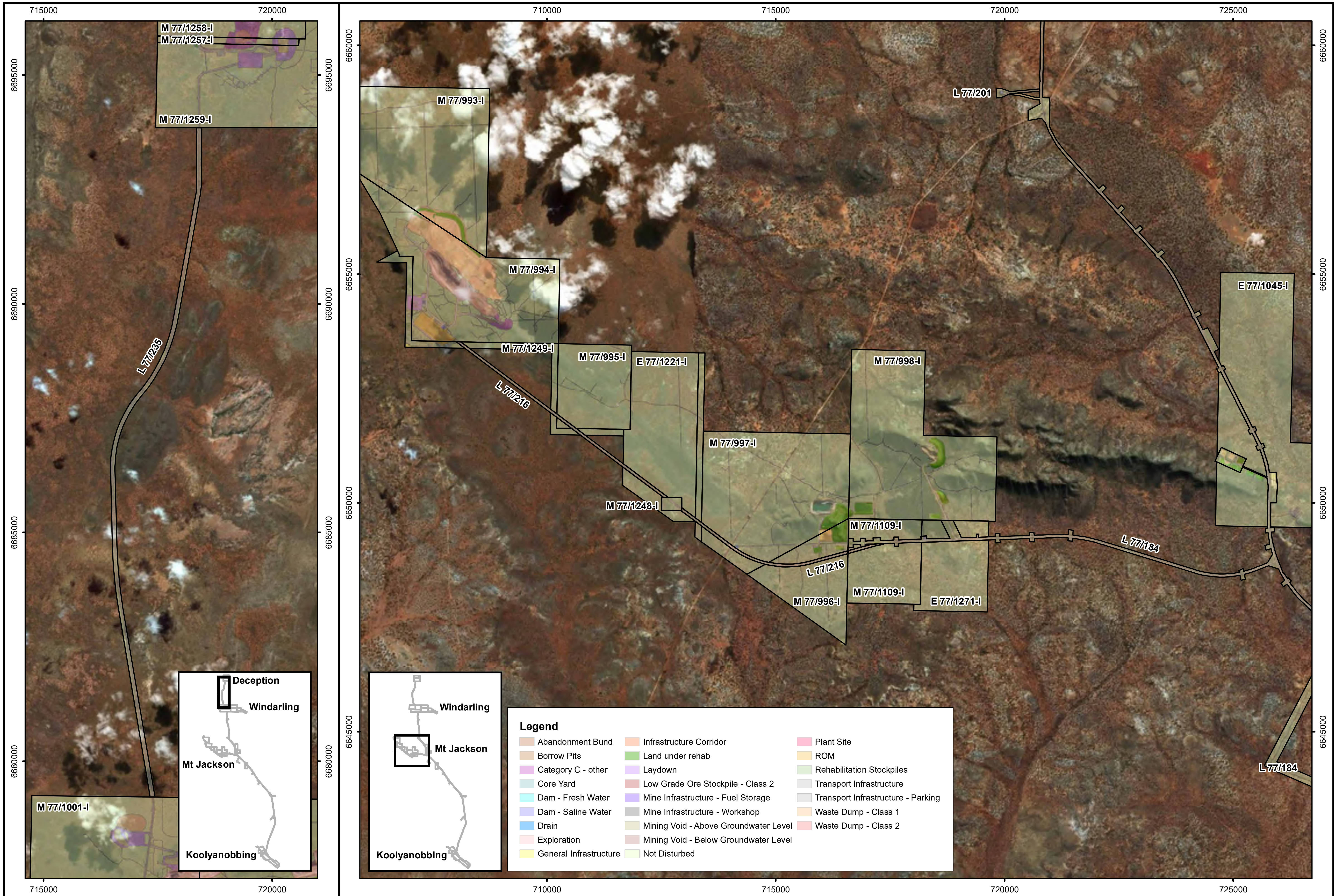
Author: N. Smith
Date: Mar 2019 | Rev: A | A3

MINERAL RESOURCES

CADRef: a2645_MRF_HaulRoad_002
Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

Yilgarn Operations
Koolyanobbing-Windarling Haul Road
2018 Clearing

Figure: 1



Imager: ESRI, DgitalGlobe (2016)

0 0.75 1.5km
Scale: 1:75,000
GDA 1994 MGA Zone 50

Author: N. Smith
Date: Apr 2019 | Rev: A | A3

CADRef: a2645_MRF_HaulRoad_003
Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

Yilgarn Operations
Mt Jackson and Deception Haul Roads
2019 MRF Category Areas

Figure: 1

Attachment 8 – Annual *Tetratheca paynterae* Monitoring Report 2018

Windarling Range 2018 Annual *Tetratheca paynterae* Monitoring

December 2018

Prepared by
Ecotec (WA) Pty Ltd for

Mineral Resources Ltd
1 Sleat Rd, Applecross, WA 6153
Koolyanobbing Operations.

Environmental solutions for MINING OIL & GAS CONSTRUCTION

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

Mineral Resources Ltd (MRL) operations include iron ore mines at the Koolyanobbing Range, Mt Jackson Range and the Windarling Range, ore processing at Koolyanobbing and road and rail transport between these operations and the Port of Esperance from where processed ore is exported. These operations were acquired by MRL from Cliffs Asia Pacific Iron Ore Pty Ltd (Cliffs) in 2018.

Tetratheca paynterae subsp. *paynterae* (hereafter referred to as *Tetratheca paynterae*) is a small shrub recorded only from within lateral cracks of the ironstone ridge at the Windarling Range. The population of *T. paynterae* at the Windarling Range is estimated to be approximately 6,341 (4,575 live) individuals extant (DBCA unpublished data). The current recorded distribution of *T. paynterae* at the Windarling Range is identified by Figure 2.1.

Tetratheca paynterae was declared as “Rare Flora” under the Wildlife Conservation Act 1950 (WA) in May 1991, and listed as a “Threatened Species” of flora under the Environmental Protection and Biodiversity Conservation Act 1999 (C’th) in July 2000. *Tetratheca paynterae* has been assessed by the Department of Biodiversity, Conservation and Attractions (formerly the Department of Parks and Wildlife (DPaW 2006)) as “Critically Endangered” using the criteria of the International Union for Conservation of Nature (IUCN 2001), and assessed by the Department of Environment and Energy (formerly the Department of Environment) as meeting the criteria for “Endangered” (DoE 2014).

The *T. paynterae* Interim Recovery Plan (IRP) (DPaW 2006) identifies management actions to ensure the ongoing viability of the species. Consistent with the IRP, Cliffs implemented a condition monitoring programme at defined monitoring blocks along the Windarling Range, in order to assess the stability and condition of the population. This monitoring program is being continued by MRL. This report documents the results of the 2018 monitoring, conducted by Ecotec (WA) Pty Ltd (Ecotec) and includes comparison to the 2011 (initial monitoring) and 2017 (previous year monitoring) results.

2.0 METHODOLOGY

2.1 Historical Monitoring

Monitoring of *Tetratheca paynterae* at the Windarling Range began in 2003 and involved a fixed sub-sample of the population monitored annually for condition. A count of the total numbers of plants (a "census") was also undertaken every five years. The results of this monitoring for the period 2003 to 2010 are outlined in the Western Botanical report *Tetratheca paynterae subsp. paynterae Annual Condition Assessment at Windarling Range during 2003 – 2010* (Western Botanical 2013). On review, it was found that this original monitoring program contained several deficiencies in its design in that it did not provide data on year-to-year trends on population numbers and did not outline death or recruitment rates.

2.2 Monitoring Design

In 2011 past monitoring data was reviewed by Data Analysis Australia (DAA) who subsequently recommended a design best suited to capturing changes in population dynamics (DAA 2011a). Monitoring since 2011 has been undertaken at seven "blocks" randomly selected by DAA as shown in Figure 2.1.

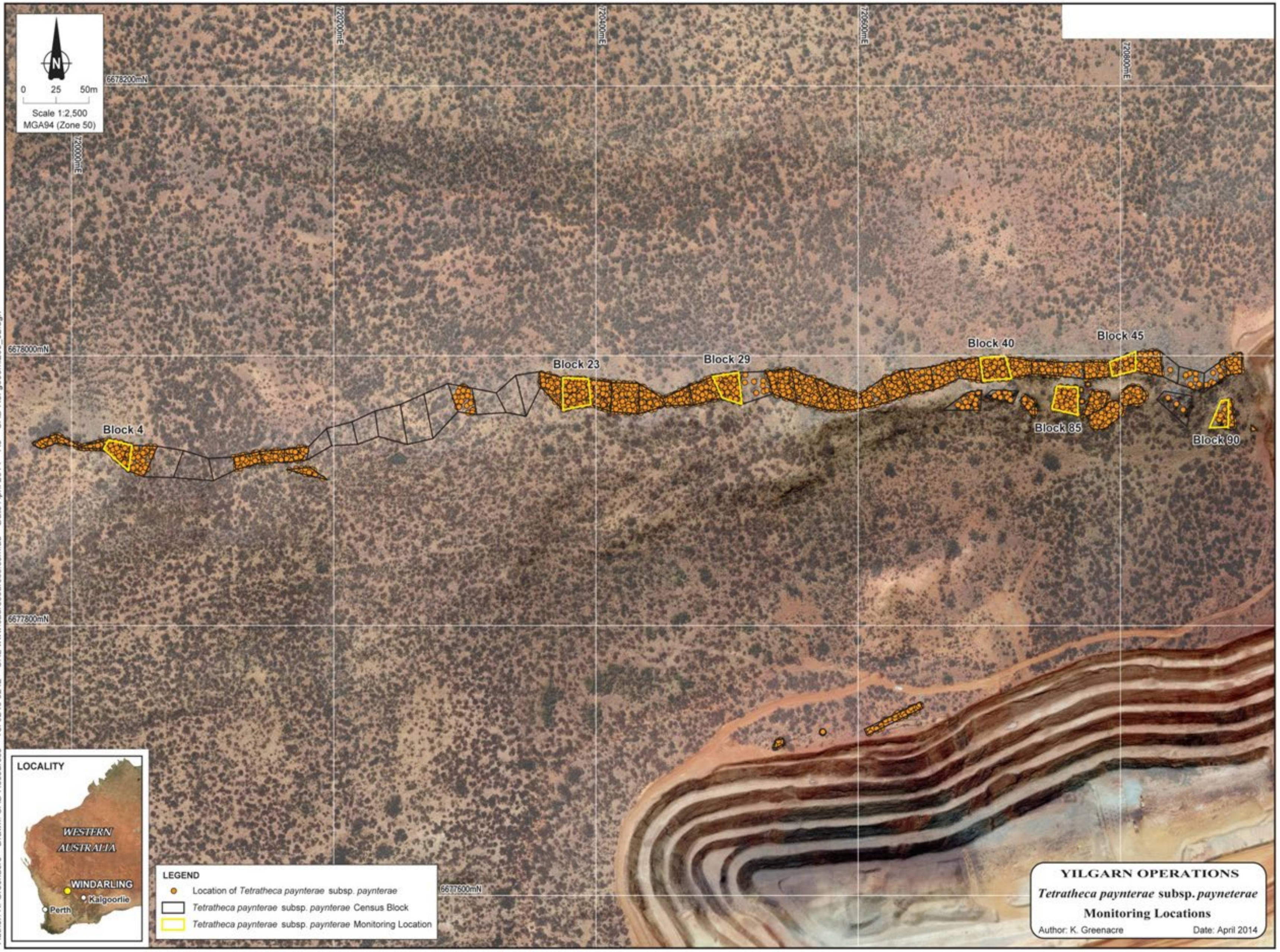


Figure 2.1: Location of *Tetratheca paynterae* showing annual monitoring blocks at Windarling.

All accessible *T. paynterae* individuals occurring within each block (including seedlings) were tagged with a unique identification number. The identification number was glued onto the rock as close as possible to the *T. paynterae* individual.

The following information was recorded for each individual:

- Block number
- Unique plant identification number
- Width (cm) (recorded for new individuals only)
- Presence of flowers/fruits/buds
- Plant status (Reproductive, Vegetative, Juvenile (1-3 years old) or Seedling (<1 year old)).

In addition, a number of individuals within each block were randomly selected for a condition assessment (percentage of total plant alive). The random selection of individuals followed the methodology outlined by DAA (2011b).

2.3 2018 Monitoring

The 2018 monitoring was conducted on 2nd and 3rd November 2018 by Ecotec personnel (two biologists and two botanists).

All blocks and *T. paynterae* individuals recorded during previous years monitoring were revisited and re-assessed for status and presence of flowers/fruits/buds. The location of any new individuals encountered within the blocks were recorded and assessed using the same method described in Section 2.2. The individuals randomly selected for condition assessment in 2011-2017 were also reassessed for condition in 2018.

Nineteen individuals were not monitored in 2018 due to not being located or were considered unsafe to access.

2.3.1 Statistical Analysis

Consistent with DAA's recommendation for condition assessment of plants (2011a), McNemar's Test Statistic was applied to test the significance of change in condition (DAA 2011c), as presented in Table 2.1.

Table 2.1 McNemars Test Statistic parameters

	Year B		
Year A	**Number of plants decreased in condition**	**Number of plants with same condition**	**Number of plants increased in condition**
	a	b	c

3.0 RESULTS

Table 3.1 presents the overall results of the 2018 monitoring and includes the results of the 2011 (initial) and 2017 (previous year) monitoring for comparison.

The 2018 monitoring recorded 1,175 *T. paynterae* individuals, of which 3 were seedlings, 13 were juveniles (1% of population), 367 were dead (31% of population), 547 were reproductive (47% of population) and 226 were vegetative (19% of population).

Table 3.1 Results of the 2011, 2017 and 2018 annual *T.paynterae* monitoring.

Plant Status/Category	2011	2017	2018
Dead	189	350	367
Seedling*	26	13	3
Juvenile*	10	7	13
Vegetative	95	205	226
Reproductive	797	595	547
Not located/not accessible	-	1	19
Total Alive	**928**	**820**	**789**
Total Population	**1117**	**1171**	**1175**
Percentage of total population alive	**83**	**70**	**67**

*Note: Seedlings recorded during one year have been considered juveniles in the following year, unless reproductive or dead.

Changes observed between the 2017 and 2018 monitoring include an increase in the number of dead individuals (by 17 individuals), a decrease in the number of new seedlings found, a decrease in the number of reproductive adults and corresponding increase in the number of vegetative adults. Twenty-one individuals recorded as dead in 2017 were alive in 2018. The total live population (789) has decreased from 820 recorded in 2017 and 928 recorded in 2011 (Figure 3.1).

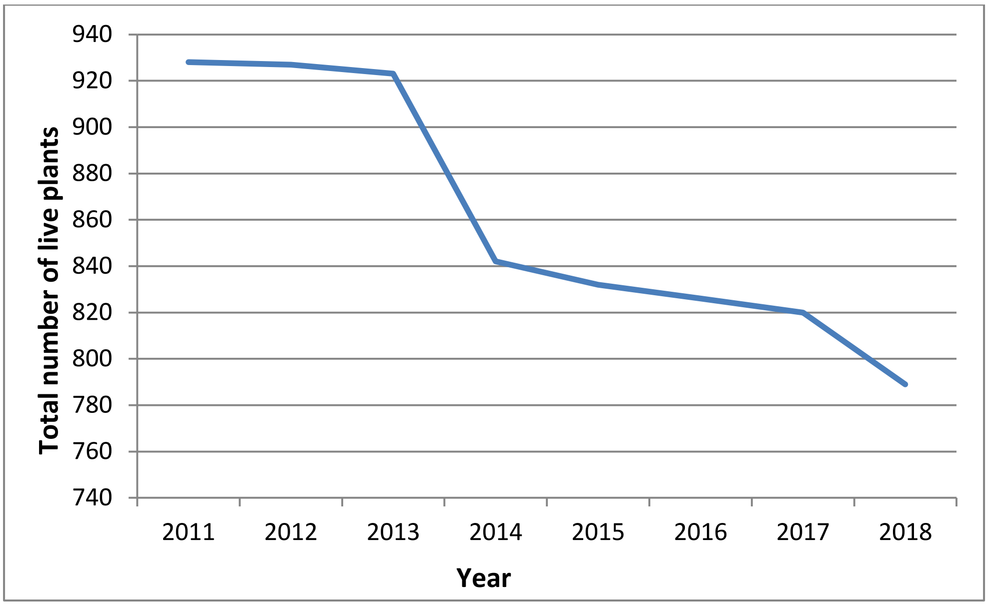


Figure 3.1 Number of live *T.paynterae* individuals recorded from 2011- 2018

3.1 Condition Assessment Individuals

The 140 individuals randomly selected for condition assessment were reassessed in 2018. The percentage of foliage alive ranged from 5% - 85% in 2018 compared to 5% - 90% in 2017.

Figure 3.2 displays the distribution of condition assessment across all categories for 2011, 2017 and 2018. Monitored individuals displayed decreased condition in 2018, with 11% of plants having an average alive foliage cover of 41% or greater, compared to 24% in 2017 and 58% in 2011.

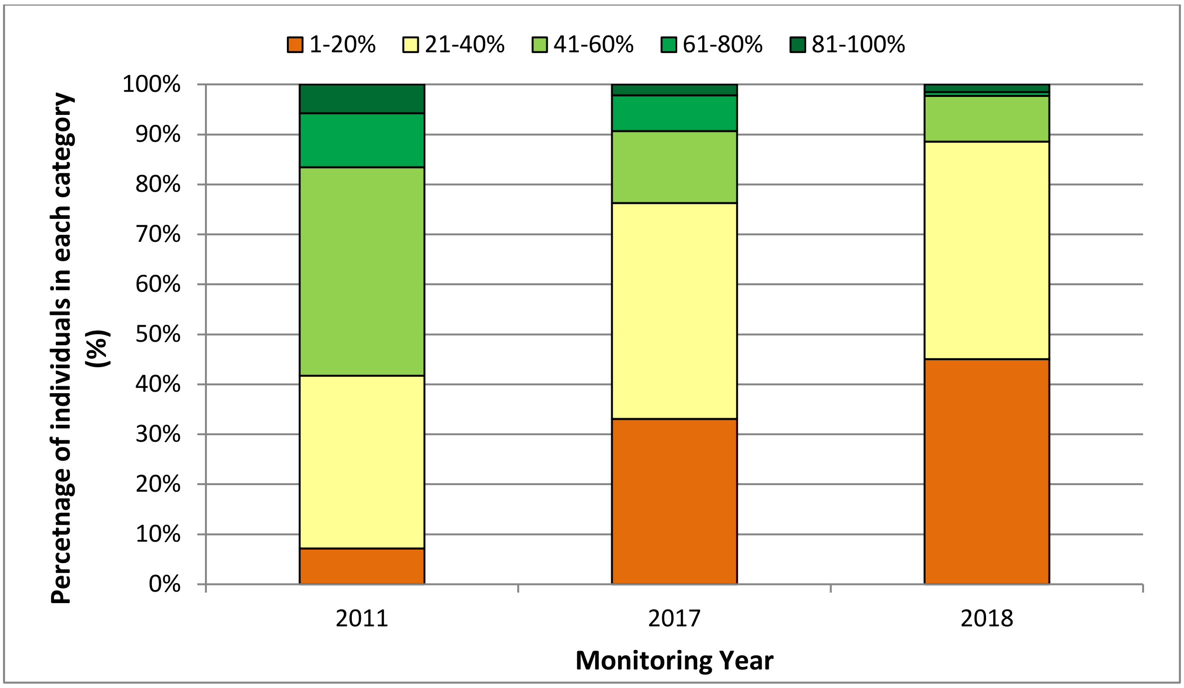


Figure 3.2 Percentage of individuals in each condition assessment category for initial, previous year and current year monitoring.

Figure 3.3 displays the average condition assessment for *T. paynterae* plants in each monitoring block and the entire population, for the 2011, 2017 and 2018 monitoring.

Average condition assessment decreased in all blocks in 2018. The average across all blocks for 2018 was approximately 23% compared with 34% recorded in 2017 and 47% in 2011. The highest average condition assessment was recorded in Block 23 (500m from pit edge) and the lowest in Block 85 (100m from pit edge).

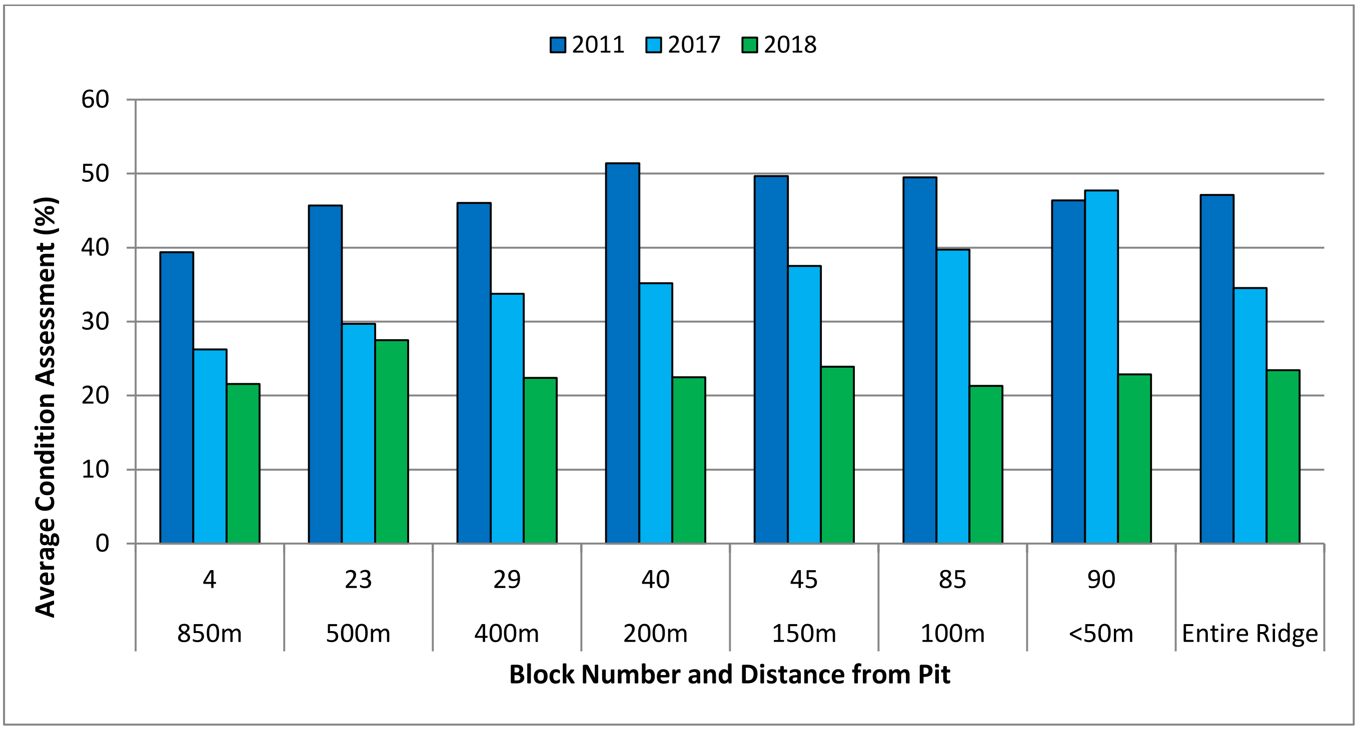


Figure 3.3 Average condition assessment in each monitoring block and entire population for 2011, 2017 and 2018.

Figure 3.4 represents the change in condition assessment between 2017 and 2018 for each block. The greatest change has occurred in Block 90 where average condition assessment has decreased by almost 25% since 2017.

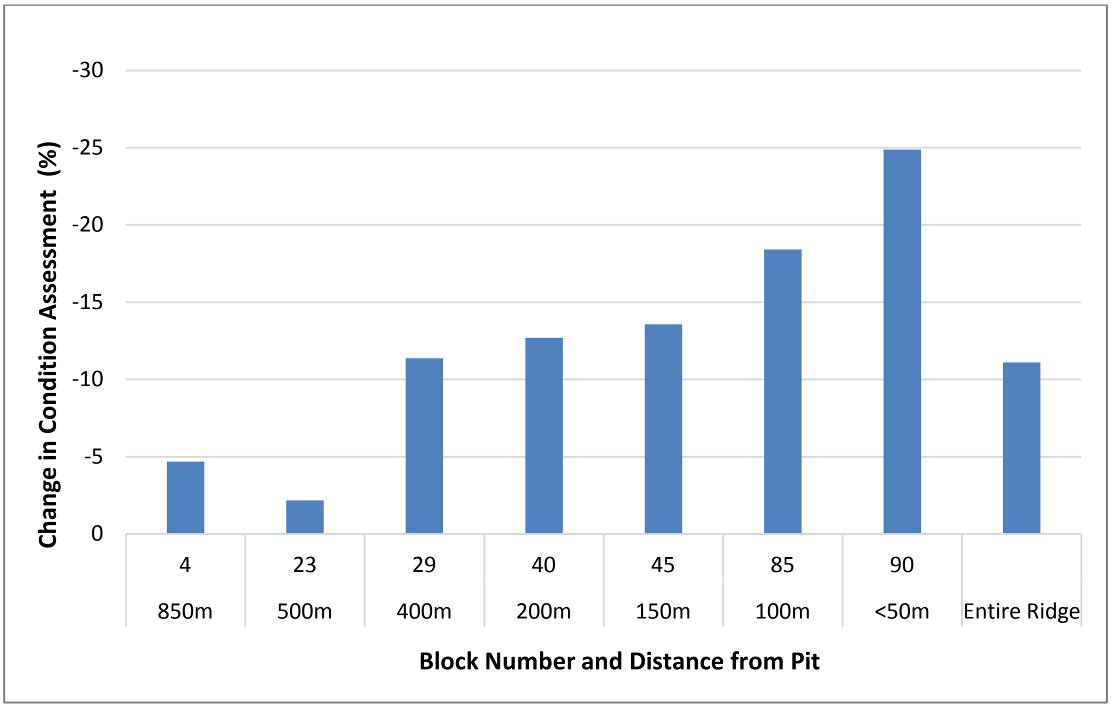


Figure 3.4 Change in condition assessment from 2017 – 2018 for each block

3.1.1 Statistical Analysis (McNemar's Test)

The McNemar's Test was applied to the results of 138 condition assessment individuals from 2017 and 2018 as outlined in Table 3.2. The results found a statistically significant change (decrease) in condition at the 5% significance level (p-value=0.0000).

Table 3.2 McNemar's test statistic applied to condition assessment change between 2017 and 2018

	Year B (2018)		
Year A (2017)	Number of plants decreased in condition	Number of plants with same condition	Number of plants increased in condition
	94	22	22

Note: The "Number of plants decreased in condition" value includes seven dead plants (condition assessment = 0%) that were alive in 2017.

The McNemar's Test was also applied to the results of condition assessment from 2011 and 2018 as outlined in Table 3.3. The results found a statistically significant change (decrease) in condition at the 5% significance level (p-value=0.0000).

Table 3.3 McNemar's test statistic applied to condition assessment change between 2017 and 2018

	Year B (2018)		
Year A (2011)	Number of plants decreased in condition	Number of plants with same condition	Number of plants increased in condition
	107	7	10

Note: The "Number of plants decreased in condition" value includes 11 dead plants (condition assessment = 0%) that were alive in 2011.

3.2 Reproductive Status

Monitoring in 2018 recorded approximately 71% of the live adult *T. paynterae* population as reproductive, a slight decrease from the 74% recorded in 2017.

Figure 3.5 displays the percentage of the reproductive population with buds, fruits and/or flowers during the 2011, 2017 and 2018 monitoring. In 2018 the majority of the reproductive population (80%) displayed flowers, 64% displayed fruits and 33% displayed buds. A greater proportion of plants displayed fruits in 2018 compared to 2017 (52%) and 2011 (60%).

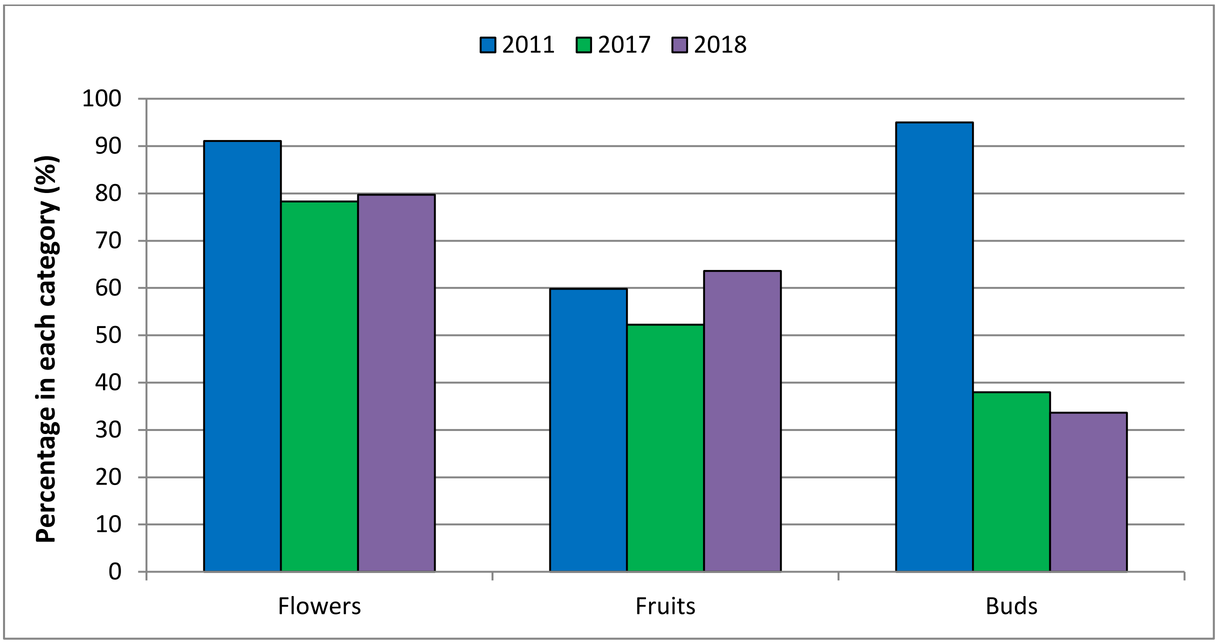


Figure 3.5 Percentage of reproductive plants with flowers, fruit and/or buds during 2011, 2017 and 2018 monitoring events.

3.3 Death and Seedling Recruitment

Figure 3.6 shows the percentage of the monitored *T. paynterae* population in each life stage (dead, reproductive, vegetative, juvenile or seedling) for the 2011, 2017 and 2018 monitoring.

There were 37 individuals recorded as newly dead between the 2017 and 2018 monitoring periods. The mortality of the population in 2018 has increased by 1.3% since 2017 (29.9% to 31.2%) and by 14.3% since 2011.

Plant deaths occurred across all monitoring blocks. Of these deaths, four were adults listed as almost dead in the 2017 monitoring. The largest number of deaths were recorded in Block 29 with 10 deaths) while the lowest number of deaths occurred in Block 90 with two deaths. Twenty one individuals counted as dead during the 2017 monitoring were recorded as alive during the 2018 monitoring. These apparently dead plants that had re-sprouted were recorded in all blocks except Block 90.

Since 2011 the greatest proportion of deaths has occurred in Block 4 with 43%, while the remaining blocks display mortality between 9% (Block 40) and 24% (Block 23).

Three new seedlings were recorded during the 2018 monitoring. Thirteen individuals recorded as seedlings in 2017 were considered juveniles in 2018.

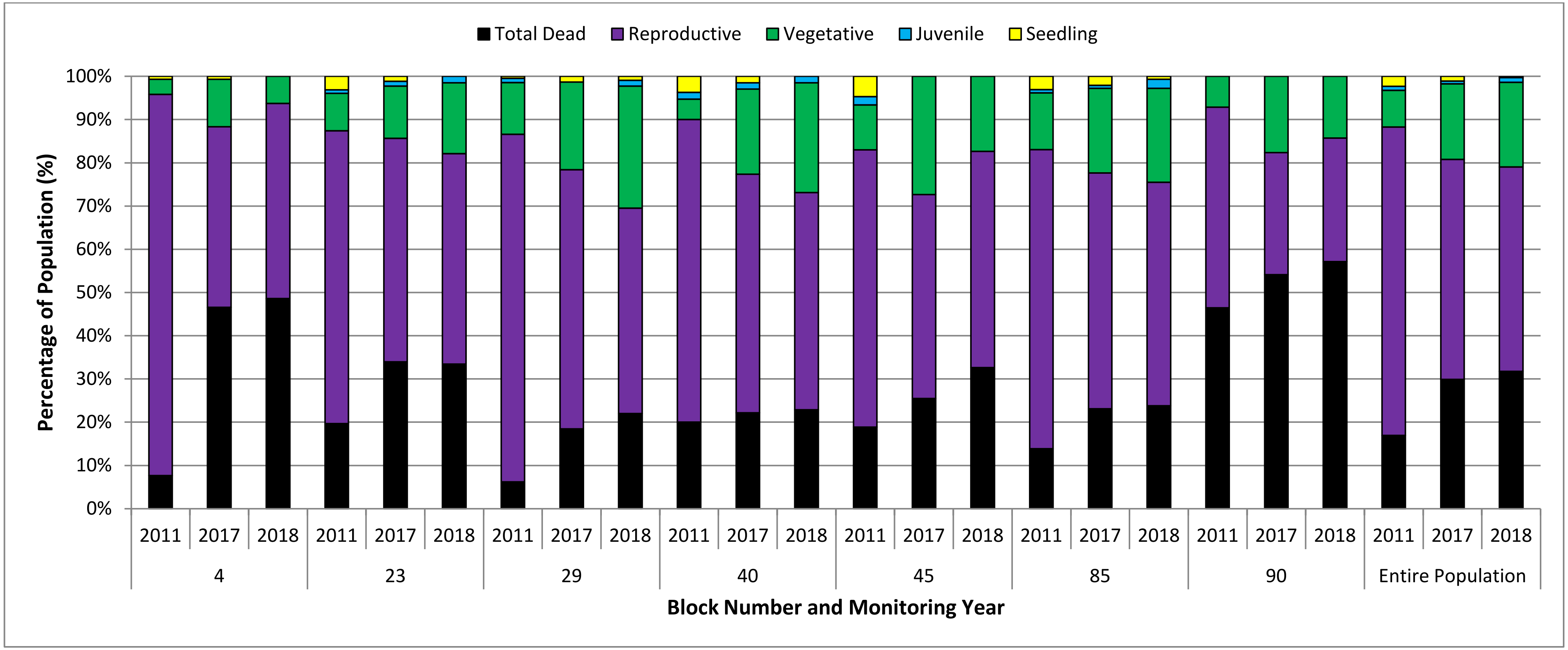


Figure 3.6 Percentage of *T.paynterae* in each life stage during 2011, 2017 and 2018 monitoring

Figure 3.7 shows the total number of live individuals per plot for each year since monitoring began in 2011.

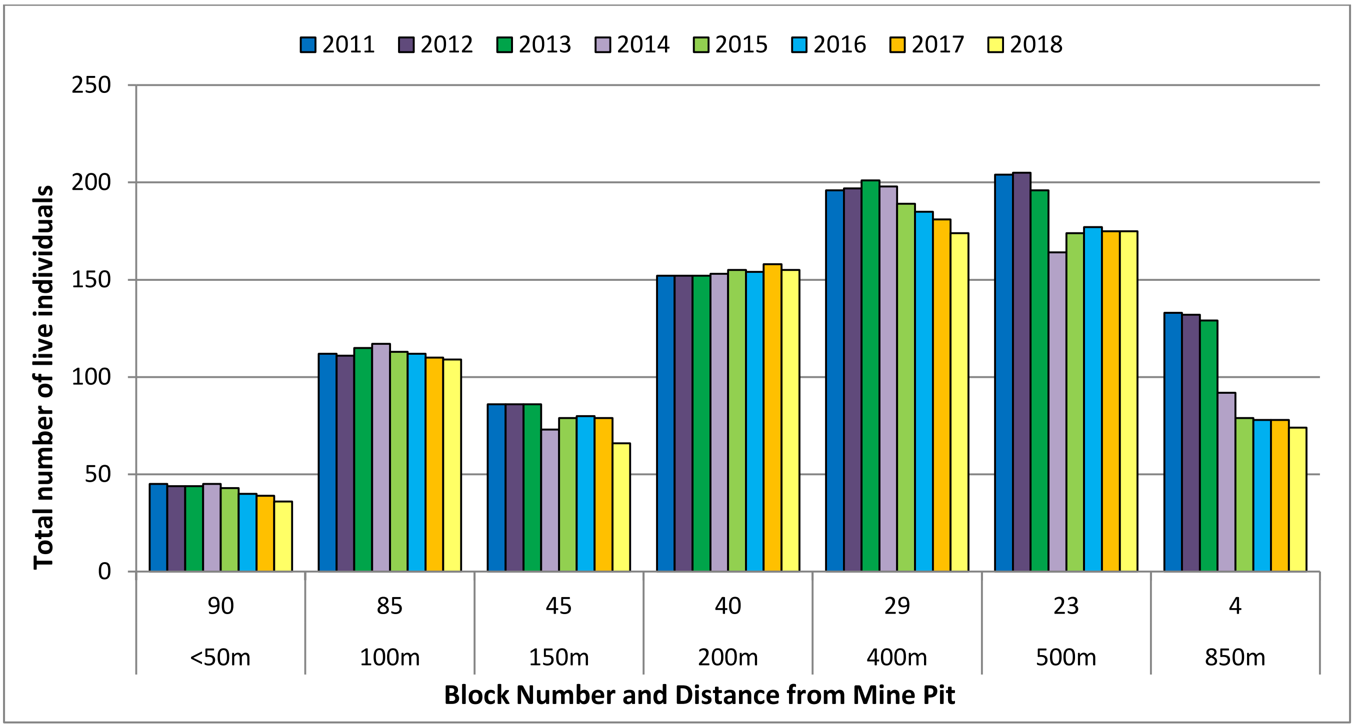


Figure 3.7 Number of live individuals in each block 2011- 2018

Figure 3.8 presents the cumulative number of individual deaths recorded during annual monitoring from 2011 – 2018 in each block. Block 4 (850m from pit edge) has recorded the greatest number of deaths, followed by Block 23 (500m from pit edge).

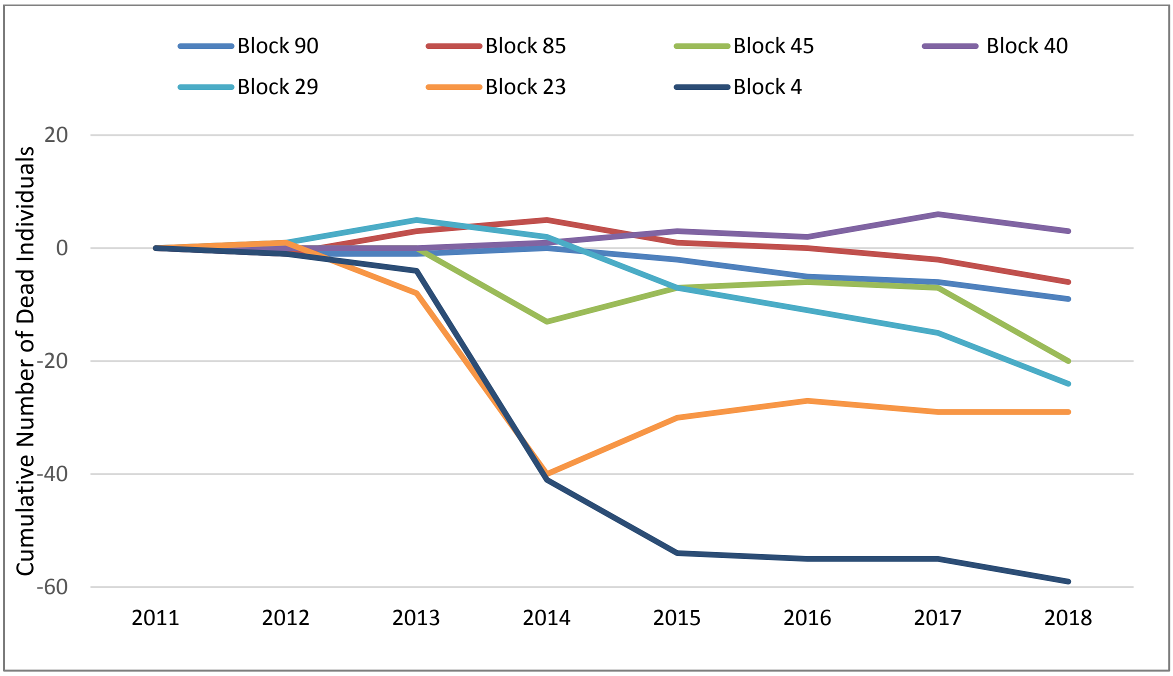


Figure 3.8 Cumulative number of deaths recorded per block since 2011.

3.4 Rainfall

The annual rainfall recorded at Windarling prior to each annual monitoring event is presented in Figure 3.9 (BoM 2018), along with the 2005-2018 average annual rainfall. In the 12 months prior to the 2018 monitoring 251.2mm of rainfall was received, lower than the 2005-2018 average of 281.6mm and lower than monitoring events in 2011 (309.5mm) and 2017 (286.2mm).

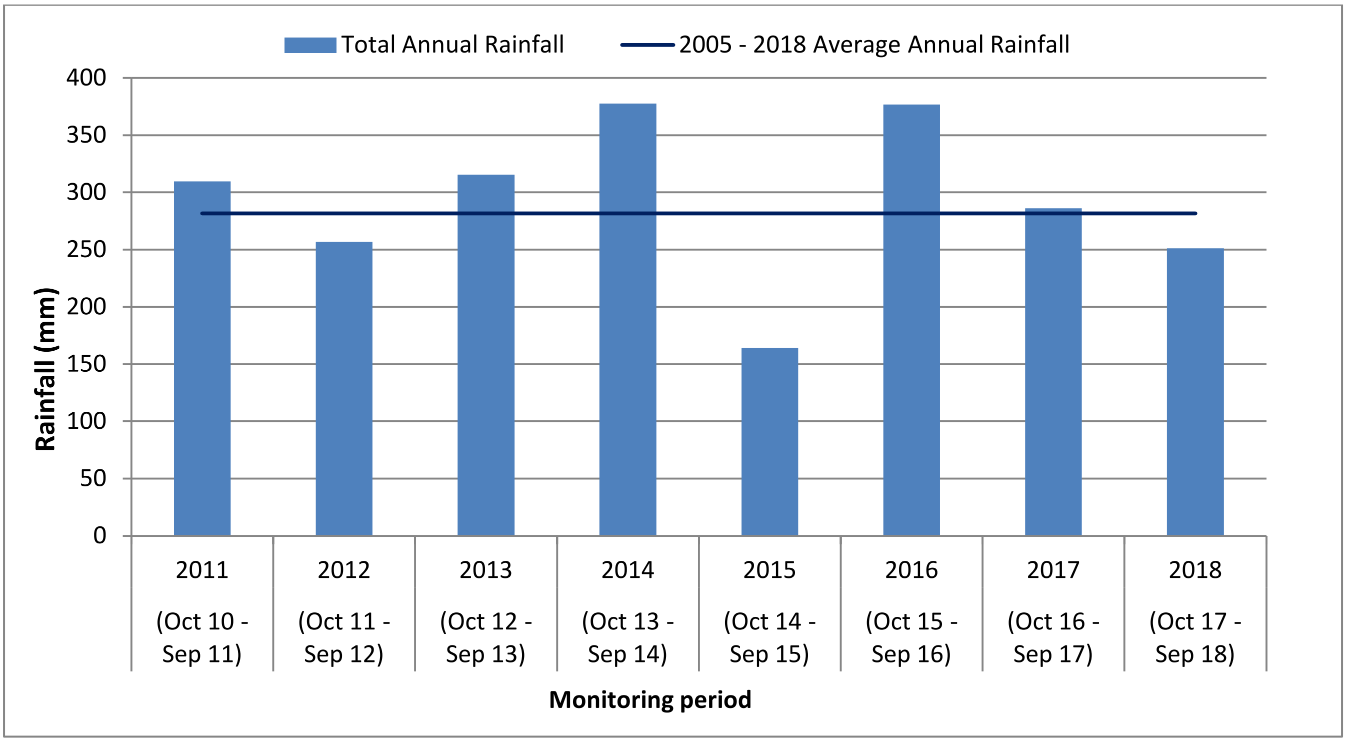


Figure 3.9 Annual rainfall received at Windarling prior to each monitoring event 2011 - 2018 and average annual rainfall for Windarling from 2005 – 2018.

Figure 3.10 displays the total monthly rainfall received at Windarling prior to the 2011, 2017 and 2018 monitoring (October – September) and the 2005-2018 monthly average (BoM 2018). No data is available for Windarling for July 2018 so the July rainfall recorded at Southern Cross airport has been substituted.

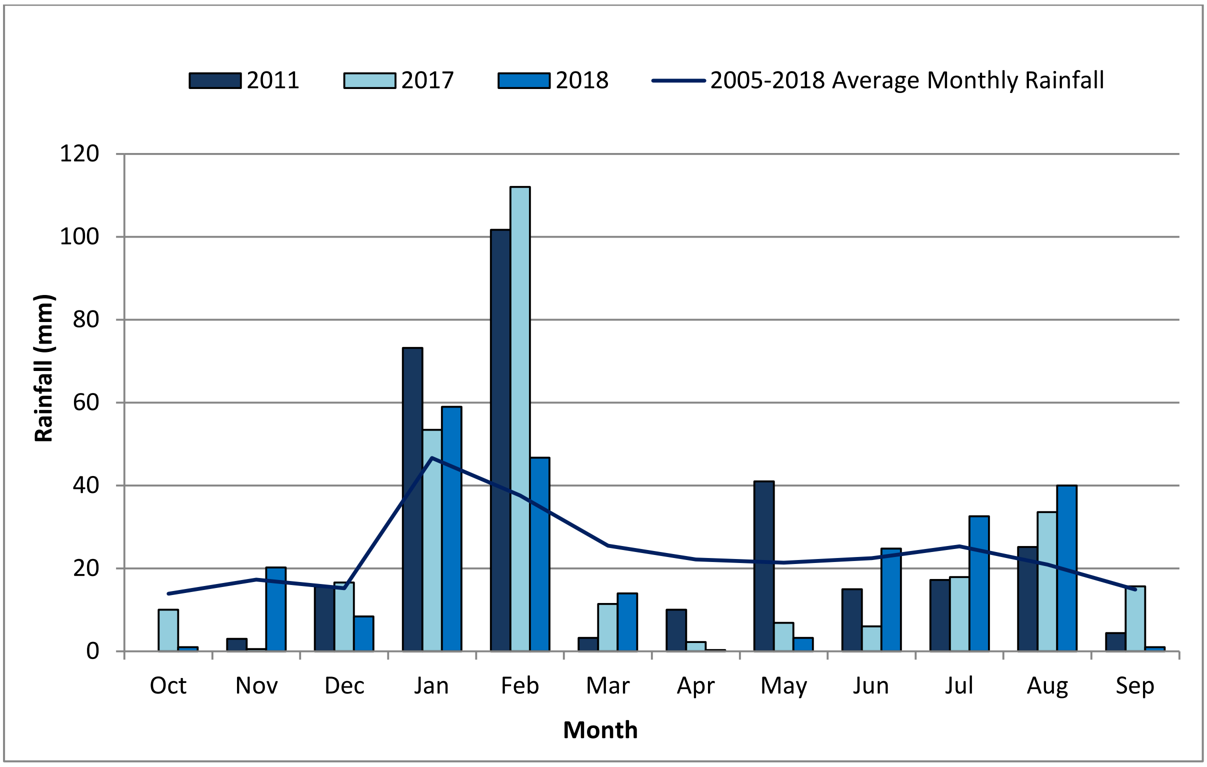


Figure 3.10 Total monthly rainfall prior to each annual monitoring event for 2011, 2017 and 2018.

4.0 DISCUSSION AND CONCLUSION

The 2018 annual monitoring found that 67% of the monitored *T. paynterae* population was alive. The total live population has decreased by 31 individuals since the 2017 monitoring. There has been a consistent low level decline in the population since 2014, however it remains reproductive and recruitment of new individuals has been recorded every year. Over 70% of the live population is reproductive - similar to the previous year. Three new seedlings were recorded in 2018 and 21 individuals recorded as dead in 2017 had re-sprouted. This indicates, and is supported by observation, that individuals may appear dead (i.e. display no live growth) but remain viable within the rock crevice and can thus re-sprout at a later date.

The average condition assessment of the entire population decreased by over 11% between 2017 and 2018 and was 24% lower than the average condition recorded in 2011. The low average condition assessment is not necessarily an indication of an unhealthy population, although the consistent decline over a number of years, with no subsequent recovery, may indicate some population stress. Block 90, the closest block to the pit, displayed the greatest decrease in condition compared to the previous year. There appears to be some correlation between decreased condition and proximity to the pit when comparing the previous year and current year, however this is not apparent when comparing the results of previous years. It should be noted that *Tetratheca paynterae* individuals retain much of their dead material for long periods of time, and older plants can often be seen with large ‘skirts’ of dead material attached to very healthy and reproductive live material.

McNemar’s statistical test to determine change in the condition of the population indicates that there has been a significant decrease in condition of the monitored individuals between 2017 - 2018, and 2011 - 2018. However, the condition assessment alone should not be used as a determinant of the health of the population, but considered in combination with other factors such as reproduction, recruitment and mortality.

The total number of deaths recorded in 2018 was 36, the highest number of deaths since 55 were recorded in 2015 and 96 in 2014. Mortality rate of the population has increased by 1.3%, a similar rate to 2017. Deaths were recorded in all blocks in 2018 with no apparent correlation between deaths and proximity to the pit. Block 90, occurring closest to the pit, recorded the least number of deaths in 2018 and second lowest overall mortality rate since 2011. While Block 4, the furthest from the pit (850m away) has the highest mortality rate since 2011, at 43%.

Mining activities occurred in the W3 pit from early 2004 to 2016 and resumed from June 2017 to March 2018. Dust monitoring results show that dust levels have been declining since 2011, as the pit deepened (Cliffs 2015). Dust levels recorded in the dust deposition gauges (DDG) along the ridge during mining in 2011 peaked at approximately 50g/m^2/month at the gauge 10m from the pit edge. There was no corresponding increase in average dust levels on W3 ridge following the resumption of mining in 2017.

Dust levels in the 12 months prior to the 2018 monitoring indicate low average levels (under 4g/m^2/month). Elevated levels were recorded in January at a DDG 10m from the pit, and in June at 100m and 200m from the pit (Figure 5.1). Records indicate that rehabilitation work was undertaken on the W3 and W4 waste dumps in February (10 days), March (8 days) and April (11 days), however these do not correlate with the dust level spikes observed. Typically the elevated dust level would be observed in the month following the activity creating the dust. Activity in the vicinity of W3 ceased on 15 April 2018. Dust levels recorded in the DDG along W3 ridge from October 2016 – October 2018 are presented in Figure 5.1.

Some previous monitoring had been correlated to wind direction and indicated elevated levels of dust deposition following periods of wind from the north and north-east. This suggests that sources of dust other than the mining operation exist, possibly from natural sources.

Slightly above average rainfall was recorded in the months following the elevated dust levels and the plants were not observed to be dusty at the time of monitoring. It is considered unlikely that the dust fluctuations contributed significantly to plant death or decreased condition in 2018.

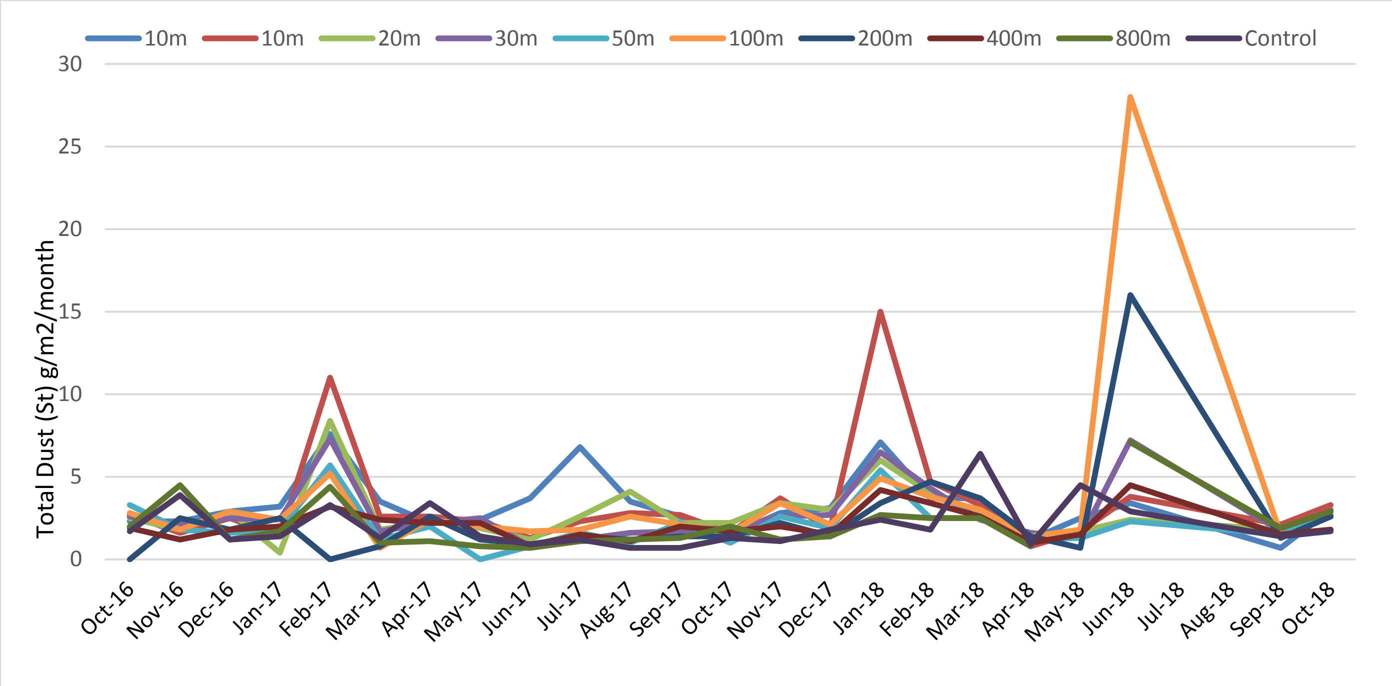


Figure 5.1 W3 Pit monthly dust deposition results October 2016 to October 2018.

Following a decline in condition and increased mortality identified in 2014, Cliffs (2015) investigated possible causes including rainfall, weather conditions, aspect (the location on the ridge where the plants are growing) and dust levels. The only correlation that was identified was the majority of plant deaths (96%) occurred to individuals growing on the north face of the ridge, which would experience the harshest climatic conditions. Examination of the growth aspect of dead individuals may provide further insight into the results of the 2018 monitoring, however further analysis of the data and detailed mapping will be required.

Like many flora taxa in arid environments, it is considered likely that the health of *T. paynterae* is closely related to changes in rainfall patterns. Good rainfall years can be expected to produce more seedlings and maintain the health of the population overall. Windarling recorded lower than average annual rainfall prior to the 2018 monitoring and very low rainfall during March, April and May. Low summer/autumn rainfall may be a key contributor to the decline in population condition and health. The higher than average rainfall received in July and August was apparently insufficient to restore condition or stimulate germination before the 2018 monitoring event.

The annual monitoring results indicate a continued decline in population health. A combination of factors are considered to have contributed to the reduced condition and increased deaths in 2018, with the main contributor believed to be lower than average rainfall. Other factors that could be further investigated include:

- growth aspect
- climatic changes
- edge effects.

Ongoing monitoring will provide additional data on the condition and size of the *T. paynterae* population and whether cessation of mining in W3 Pit contributes to an increase in population health.

4.1 Comparison of Results against Trigger Criteria

Cliffs Flora and Vegetation Management Plan (2016) outlines trigger criteria that require further reporting and contingency actions. The following section compares the results of the 2018 monitoring against the relevant trigger criteria.

1. *Annual monitoring indicates a decline of greater than 15% in plant condition relative to the previous year; and rainfall is >150mm between annual sampling dates (i.e. the change is unlikely to be a result of drought conditions).*

The 2018 monitoring found plant condition decreased by 11.1% since the 2017 monitoring, as shown in Figure 3.3 and outlined in Section 3.1. Low average rainfall received during March to May 2018 is most likely a key contributor to the decline.

This trigger has not been exceeded.

2. *Annual monitoring indicates a mortality of greater than 10% of the sampled population since the previous year and rainfall is >150mm between annual sampling dates.*

Mortality increased by approximately 1.3% between the 2017 and 2018 monitoring.

This trigger has not been exceeded.

3. *Annual monitoring indicates a consistent pattern of decline in population numbers over a longer time scale (2+ years).*

There has been a consistent decline over a six year period. With the exception of the 2014 monitoring where a 7.9% decline was recorded, the decline each year has been less than 2%. According to Cliffs (2015) the decline in 2014 was unlikely to have been a result of mining activities. Investigation found that most deaths occurred on the exposed north face of the ridge which would experience harsher climatic conditions. Dust levels had decreased during this monitoring period, suggesting dust from mining wasn't a contributor to the decline. A consistent small decline is not an unexpected pattern given that *Tetratheca* species in the Yilgarn area are known to be long-lived and likely to be pulse recruiters, characterised by infrequent replenishment of population numbers (Cliffs 2018).

This trigger has been exceeded and further reporting may be required.

4. *Annual monitoring indicates a spatial pattern of decreasing plant condition and/or higher mortality that may be related to proximity to mining operations.*

There is currently no correlation between distance from mine pit and mortality, as shown in Figure 3.6, Figure 3.7 and Figure 3.8.

Comparisons of plant condition between the previous year and current year indicate a pattern of decreased condition in blocks closer to the pit, as shown in Figure 3.4.

This trigger, as it relates to decreased condition, has been exceeded and further reporting may be required.

5. *Any direct effect on Rare Flora occurs as a result of mining activities e.g. unauthorised ground disturbance, fire.*

No direct impact to *Tetratheca paynterae* individuals has occurred as a result of mining activities.

This trigger has not been exceeded.

6. *Any significant short term (i.e. < 1 year) decline in Rare Flora is detected at any time.*

No significant short term decline has been identified in the *Tetratheca paynterae* population.

This trigger has not been exceeded.

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Attachment 9 – Annual *Ricinocarpos brevis* Monitoring Report 2018

2018 ANNUAL *RICINOCARPOS BREVIS* MONITORING AT WINDARLING

PREPARED FOR:

MINERAL RESOURCES LIMITED

JANUARY 2019

PREPARED BY:

Martinick Bosch Sell Pty Ltd
4 Cook Street
West Perth WA 6005
Ph: (08) 9226 3166
Fax: (08) 9226 3177
Email: info@mbsenvironmental.com.au
Web: www.mbsenvironmental.com.au

MARTINICK BOSCH SELL PTY LTD

ABN 60 102 614 479

MBS ENVIRONMENTAL

environmental and geoscience consultants

2018 ANNUAL *RICINOCARPOS BREVIS* MONITORING AT WINDARLING JANUARY 2019

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Company	Contact name	Copies	Date
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Final Report (Revision 3)	Thomas Robson	Kristy Sell	18 January 2019

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1. INTRODUCTION

Ricinocarpos brevis is a non-lignotuberous upright shrub from the Yilgarn Region of Western Australia, which has been recorded in three populations located at the Windarling, Johnston and Perrinvale Ranges. *Ricinocarpos brevis* occurs across the length of the Windarling Range, including areas traversing approved mining areas. In 2005, following the commencement of mining at Windarling Range in 2004, *R. brevis* was declared as 'Threatened Flora' under the *Wildlife Conservation Act 1950* (WA).

The former operators of the Mineral Resources Limited (MRL) iron ore operations at Windarling, Cliffs Asia Pacific Iron Ore Pty Ltd (Cliffs) contributed to the development of an Interim Recovery Plan (IRP) for *R. brevis* that identifies management actions to ensure the ongoing viability of the species. Monitoring population stability (expansion or decline) is one such recovery action listed within the document (DEC 2011).

In line with the commitments of the previous operator, MRL commissioned MBS Environmental (MBS) to monitor transects along the Windarling Ridge in order to assess the stability of the population. The objective of this report is to document and discuss the results of the 2018 population monitoring event and compare them with results from the previous year (2017) and baseline (2010) year[1].

[1] The baseline year is 2011 for some comparisons (e.g. condition assessment using the method established and used from 2011 onwards).

2. METHODS

2.1 HISTORICAL MONITORING

Monitoring of *R. brevis* at the Windarling range began in 2003, at a time when little was known of the biology of the species. Annual monitoring of a fixed sub-sample of the population, including plant condition and a count of the total numbers of plants, was completed every five years (i.e. a 'census'). However, this did not provide data on year-to-year trends on population numbers, and did not outline death or recruitment rates. Cliffs engaged Data Analysis Australia (DAA) to review past monitoring data and to recommend a design best suited to capturing population dynamics (DAA 2010).

Following the design recommended by DAA, ten transects were established along the Windarling Ridge in 2010 (Figure 1). These transects were 20 m wide and varied in length depending on the existence of *R. brevis* (i.e. the transect finished with the *R. brevis* population). Transects were divided into 10 m long quadrats for ease of monitoring.

The 2010 monitoring event was conducted between June and September, during which time all *R. brevis* individuals occurring within each transect were tagged with a unique identification number and the height and reproductive status (seedling, juvenile, vegetative, reproductive or dead) of each individual was recorded. Randomly selected individuals were also given a condition assessment (percentage of total plant alive).

DAA recommended that a subsample of at least 200 individuals should be assessed for condition during each monitoring event to adequately represent the population, and developed a method for randomly selecting plants for condition assessment in order to avoid bias (DAA 2010, 2011a).

Since 2011, the ten transects established along the ridge have been revisited on an annual basis, and all individuals (previously tagged) were monitored for reproductive status and the presence/absence of flowers, fruits and buds. Height measurements were recorded for plants less than 50 cm tall. Using the recommended method for selecting plants for condition assessment, 215 individuals were randomly selected and their condition assessment recorded. Any new plants (without a tag) discovered during the monitoring were tagged with a unique identification number and assessed using the same methodology.

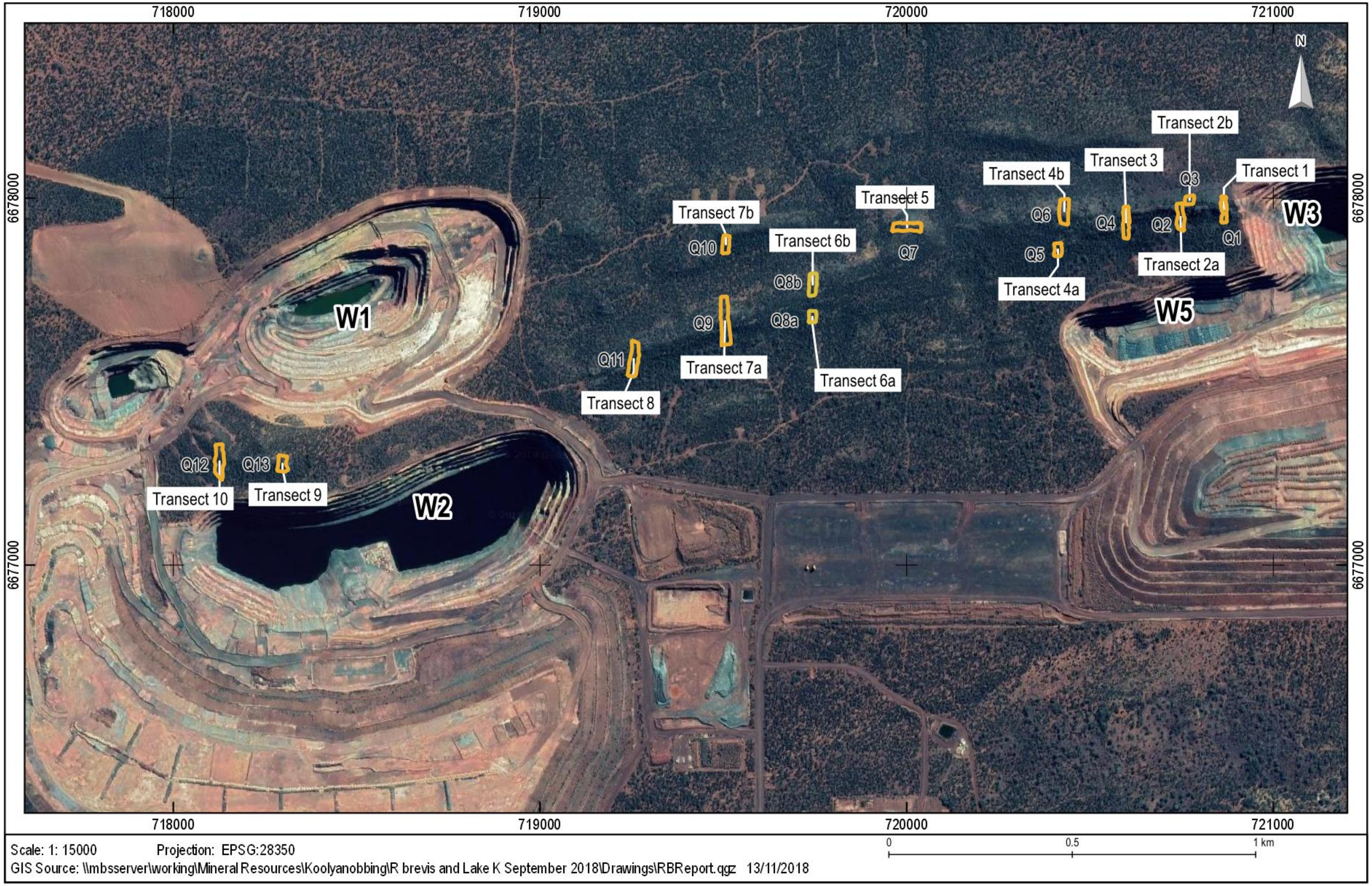

Figure 1: Location of *Ricinocarpos brevis* Annual Monitoring Plots

2.2 CURRENT MONITORING

The 2018 monitoring was conducted between 10 and 16 September 2018 by Michel Dufty (Senior Environmental Engineer), Stephanie Stack (Graduate Environmental Scientist) and Arielle Fontaine (Environmental Scientist). The ten transects established along the ridge were revisited, and all individuals (previously tagged) were monitored for reproductive status and the presence/absence of flowers, fruits and buds. Height measurements were recorded for plants less than 50 cm tall. The 215 individuals randomly selected (in 2011) for condition assessments were also reassessed.

Since 2011, seedling searches have been conducted in autumn (circa April) of the year following monitoring, when annual species are no longer present, therefore making identification of small seedlings easier. In 2018, the seedling searches were conducted by MRL personnel in December due to logistical issues associated with the transition in the project operator (i.e. from Cliffs to MRL). Advice from the Department of Biodiversity, Conservation and Attractions (DBCA) supported the belated seedling search, based on observations of good recruitment in other priority taxa within the operations areas (Neil Smith, Environment Superintendent, pers. com).

From 2011 onwards, individuals have been considered seedlings if not present during previous monitoring, and juveniles have been considered 1-3 years of age. After three years, individuals are considered adults.

2.3 STATISTICAL ANALYSIS

As part of DAA's recommendation for condition assessment of plants, it was advised that McNemar's Test Statistic should be applied to test the significance of changes in condition (DAA 2011b). The conceptual structure of this test is shown in Table 1.

Table 1: McNemar's Test Statistic Applied to Condition Assessment Results

	Year B		
Year A	Number of Plants Decreased in Condition	Number of Plants in Same Condition	Number of Plants Increased in Condition
	a	b	c

**Applied at the 5% significance level, p-value =0.0621*

3. ENVIRONMENTAL FACTORS

The following subsections describe the key environmental factors that are considered relevant to the health of the *R. Brevis* population at Windarling, namely rainfall and the level of mining activity in proximity to the monitoring plots.

3.1 RAINFALL

The annual rainfall recorded at Windarling in the 12 month period (usually between July and June) prior to each monitoring, as well as average annual rainfall (2005 - 2017) is shown in Figure 2 (BoM 2018)[2]. The rainfall data for 2018 are presented for the period between September 2017 and August 2018, since the 2018 monitoring event was completed in September as opposed July, when it has been completed in previous years.

Windarling received 243 mm of rainfall in the 12 months prior to the 2018 monitoring event (September 2017 – August 2018), which was less than the long-term average of 279 mm (2010 – 2018). This followed above-average rainfall prior to the 2017 (293 mm) and 2016 (336 mm) monitoring events.

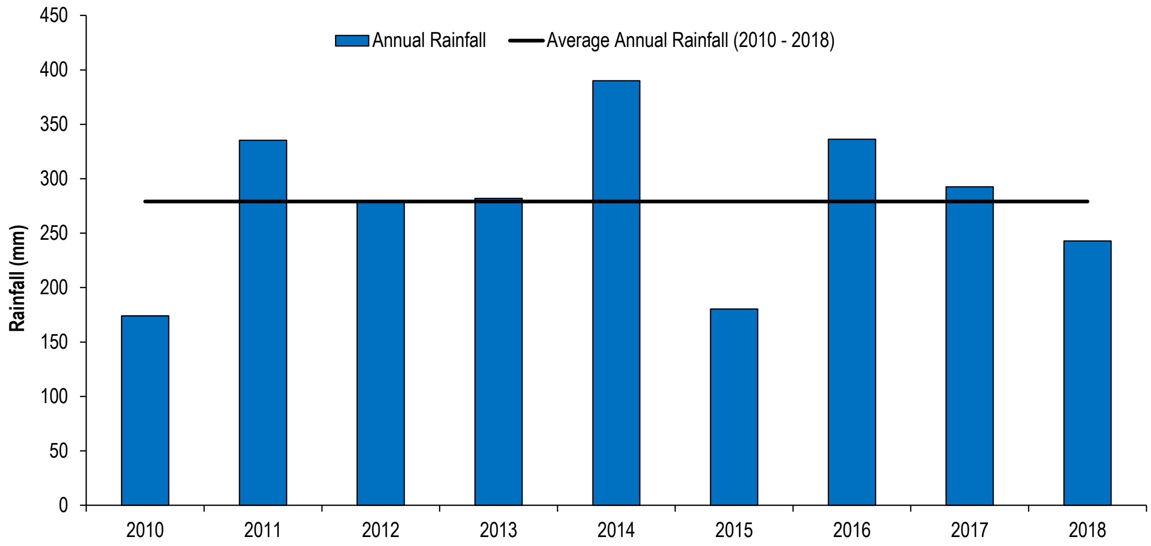

Figure 2: Total Rainfall Recorded Prior to Annual Monitoring Events at Windarling

The total monthly rainfall recorded at Windarling for the 2010 (initial), 2017 (previous year) and 2018 (current year) monitoring seasons are presented in Figure 3, along with average monthly rainfall recorded between 2005 and 2018 (BoM 2018). Rainfall during the 2018 monitoring season (September 2017 – August 2018) was at or above the long-term monthly average for seven months (September and November 2017; January, February, June, July and August 2018), compared with five months prior to the 2017 monitoring season. Note that rainfall between March and May 2018 was substantially lower than average, as it was leading up to the 2017 monitoring event.

2 The Windarling rain gauge was not read between 26 June and 10 August 2018 since the site was unattended. The rainfall for August 2018 (50.3 mm) represented this entire period; therefore, the total August rainfall was split evenly between July (25.1 mm) and August (25.2 mm) 2018 for purposes of comparing monthly rainfall with long-term averages.

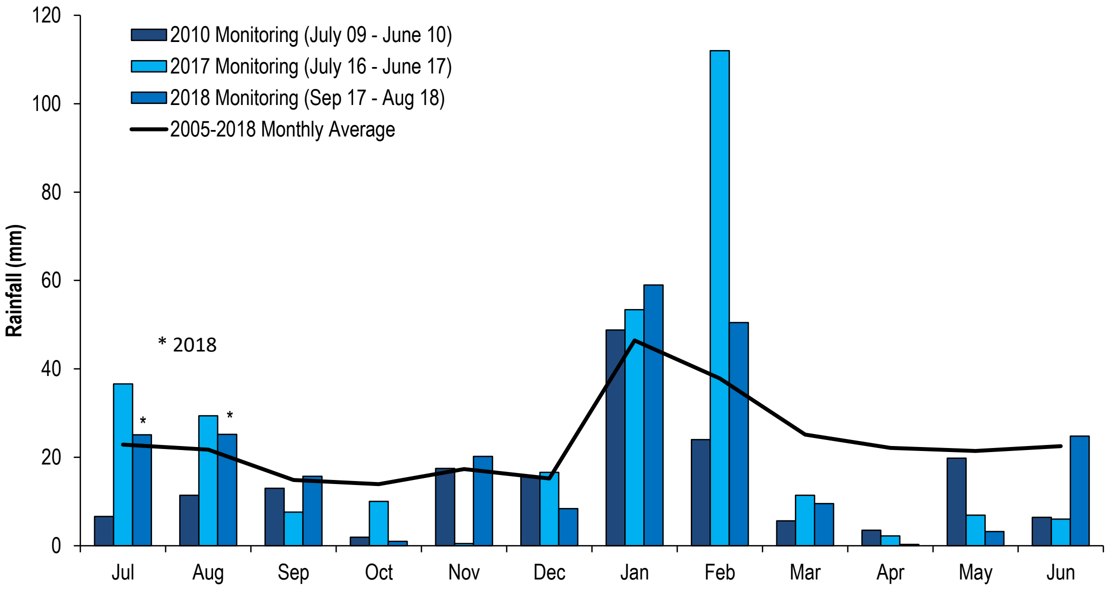

Figure 3: Monthly Rainfall for 2010 (Initial), 2017 (Previous Year) and 2018 (Current Year) Monitoring Seasons at Windarling

3.2 PIT ACTIVITY

The volumes of material removed from each of the Windarling pits located nearby the *R. brevis* monitoring plots (W1, W2 and W3/W5 pits – see Figure 1) is presented in Figure 4. These volumes provide an approximate measure of the level of mining activity and therefore potential impacts upon the *R. brevis* population (e.g. from dust emission). The key trends in mining activity are summarised below:

- W1 pit (including W1 East and W1 West) was most actively mined between December 2011 and June 2015. Mining in W1 pit ceased in March 2017 (W1 East in March 2107 and W1 West in February 2014).
- W2 pit was most actively mined between 2007 and 2014, with minimal extraction between June 2014 and July 2018.
- W3 (incorporating W5) pit has been mined continually between August 2007 and March 2018, most actively between August 2007 and May 2010, and then between September 2010 and June 2015. Extraction from W3 pit has been minimal since June 2015.

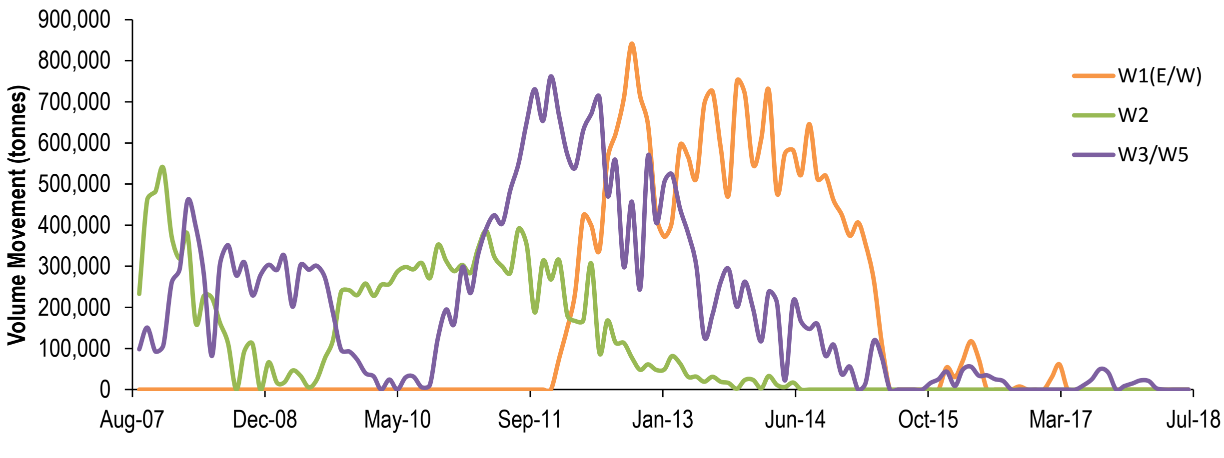

Figure 4: Windarling Pit Volume Movements (September 2007 – July 2018)

4. RESULTS

Table 2 presents the results of the 2010 (initial), 2017 (previous year) and 2018 monitoring events. The 2018 monitoring included 1,626 individuals; of which 19 were seedlings (1.2% of population). Six individuals were juveniles (<1% of population), 208 were dead (12.8% of population); 826 were reproductive (58.6% of live population) and 559 were vegetative (39.6% of live population). The total population monitored increased by 24 individuals, compared with 2017.

Table 2: Summary of Results from 2010 (Initial), 2017 (Previous Year) and 2018 Annual Monitoring Events

Plant Status/Category	2010	2017	2018	Relative Change 2018 - 2017	Relative Change 2018 - 2010
Seedlings	5	1	19	18	14
Juveniles	568	7	6	-1	-562
Vegetative	306	692	559	-133	253
Reproductive	639	708	826	118	187
Dead	20	191	208	17	188
Not Found	-	3	8	5	8
Total Live Population	**1,518**	**1,408**	**1,410**	**2**	**-108**
Total Population	**1,538**	**1,602**	**1,626**	**24**	**88**
% Total Population Alive	**98.7%**	**87.9%**	**86.7%**	**-0.9%**	**-12.0%**

Changes observed between the 2018 and 2017 monitoring events include:

- An increase in the size of the live population (additional two individuals).
- An increase in the number of seedlings (additional 19 seedlings).
- An increase in the number of dead individuals (additional 17 individuals).
- An increase in the number of reproductive adults (additional 118 individuals).
- Decrease in the number of vegetative adults (133 fewer individuals).

The total live population size remained relatively stable between 2010 and 2014; however, a marked decrease was observed during the 2015 and 2016 monitoring events. The 2017 and 2018 monitoring results suggest that this trend has begun to stabilise, with annual variations in live population returning to around 1% compared with around 3% in 2015 and 2016 (Figure 5).

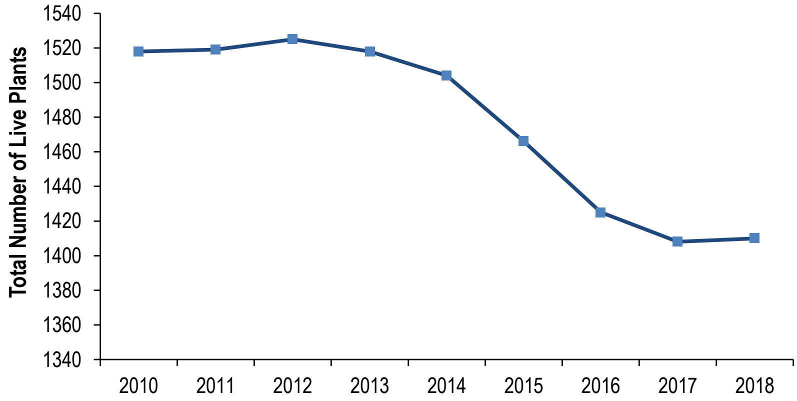

Figure 5: Total Number of Live Plants in Monitored Transects (2010-2018)

4.1 CONDITION ASSESSMENT

The 215 individuals randomly selected for condition assessment were reassessed in 2018. As condition assessment (as recommended by DAA) was not conducted until 2011, the 2011 results have been used as baseline for annual comparisons.

The average condition across the monitoring transects for both 2017 and 2018 monitoring events was between 80 and 81%, very similar to the 80% recorded when assessment monitoring began in 2011.

Figure 6 presents the percentage of assessed individuals assigned to each condition category during the 2011, 2017 and 2018 monitoring events. Approximately 85% of the condition assessment plants were ranked in the top two categories (having an average live foliage cover of 61% or greater) in 2011, compared with 86% in 2017 and 82% in 2018. Between 2011 and 2018, the number of individuals in the top category (81-100% alive) varied between 112 in 2011 and 149 in 2014, indicating that the 113 individuals assigned to this category in 2018 fell within the range of the existing monitoring results. The number of individuals assigned to the 61-80% alive category (59) was also within the range recorded in previous years (43 – 69), whereas the number of plants assessed as 41-60% alive (32) was the highest yet recorded (18-25 between 2011 and 2017).

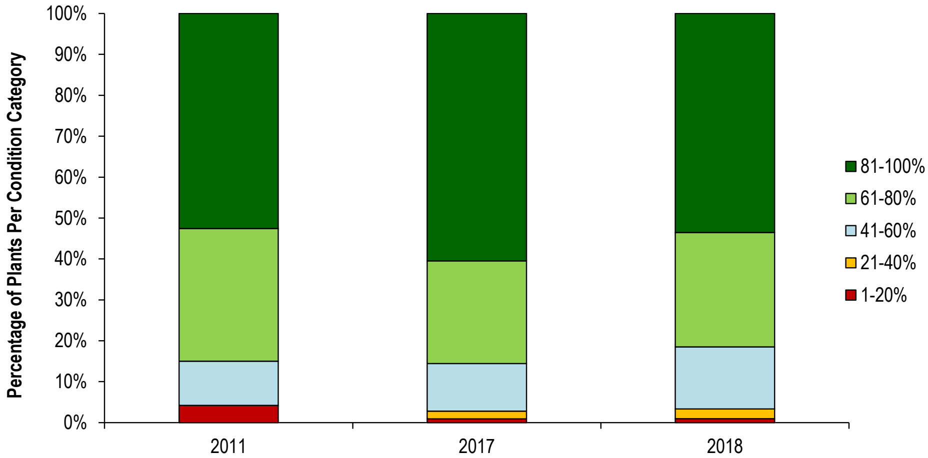

Figure 6: Percentage of Assessed Individuals Assigned per Condition Category

Figure 7 presents the average condition assessment for *R. brevis* individuals in each of ten monitoring transect locations, as well as for the entire monitored population (i.e. "Entire Ridge") for the 2011, 2017 and 2018 monitoring events. When compared to results from 2017, the 2018 monitoring found:

- The average condition of the entire ridge assessed during 2018 (80.3%) was similar to that recorded in 2017 (81.2%) and 2011 (80%).
- Six transects with minor decreases in average condition (by between 1.4 and 3.8%).
- Four transects with increased average condition (by 0.6 – 1.9%).
- Average condition based on transect location ranged between 74.4% (T10) and 89.0% (T2) in 2018, compared with between 77.0% (T9) and 87.0% (T2) in 2017, and between 75.0% (T4) and 86.6% (T2) in 2011.
- No transect has consistently been considered the least healthy across all years of monitoring, although transect two (T2) has been assessed as the healthiest during all years of monitoring (Figure 7).

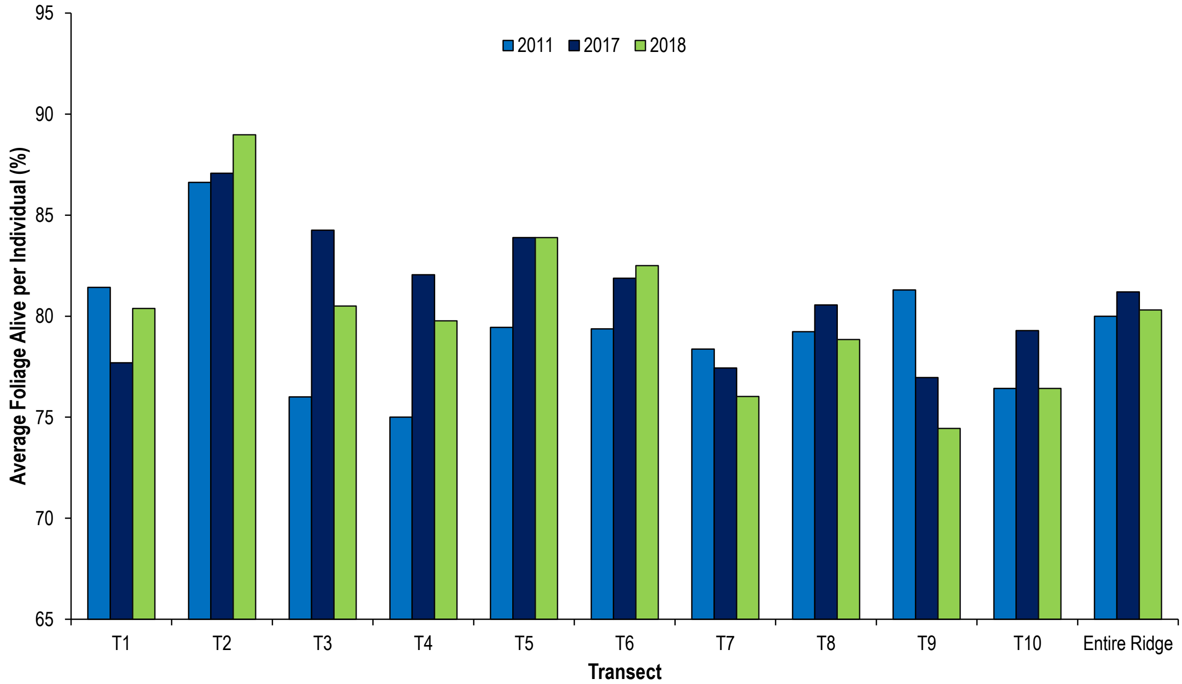

Figure 7: Average Condition Assessment of Individuals per Transect Location for 2011 (Initial), 2017 (Previous Year) and 2018 Monitoring Events

The McNemar's and two-tailed binomial statistical tests were used to test the significance of relative changes in plant condition observed between the 2018 and 2017 monitoring events (Table 3). The results indicated that there was a statistically significant change (i.e. overall average decrease) in condition at the 5% level between the 2018 and 2017 monitoring events.

Table 3: McNemar's Test Statistic for Relative Changes in Condition Between 2018 and 2017 Monitoring Events

	Year B		
Year A	Number of Plants Decreased in Condition	Number of Plants in Same Condition	Number of Plants Increased in Condition
	62	111	38

**Applied at the 5% significance level, p-value = 0.0210, McNemar's test statistic = 5.523*

The same statistical tests were also applied to determine the significance of relative changes in plant condition observed between the 2018 and 2011 monitoring events (Table 4). The results indicated that there was no evidence for a significant change in condition at the 5% level between the 2011 and 2018 monitoring events.

Table 4: McNemar's Test Statistic for Relative Changes in Condition Between 2018 and 2011 Monitoring Events

	Year B		
Year A	Number of Plants Decreased in Condition	Number of Plants in Same Condition	Number of Plants Increased in Condition
	64	50	89

**Applied at the 5% significance level, p-value = 0.0635, McNemar's test statistic = 3.898*

4.2 REPRODUCTIVE STATUS

Figure 8 presents the percentage of the reproductive population that displayed buds, fruits and/or flowers during the 2011, 2017 and 2018 monitoring events.

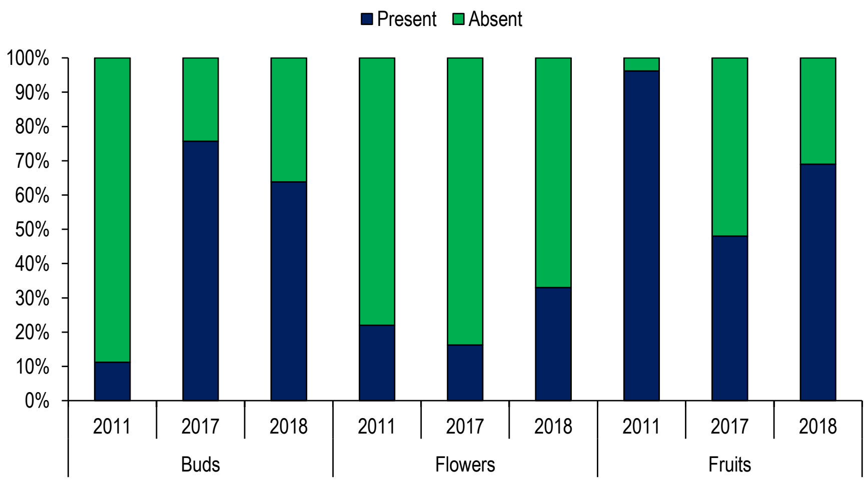

Figure 8: Percentage of Reproductive *R. brevis* Displaying Reproductive Bodies in 2011 (Initial), 2017 (Previous Years) and 2018 (Current Year)

The 2018 monitoring reported a higher percentage of the reproductive population with flowers (33%) than during both 2011 (22%) and 2017 (16%) monitoring events. The 2018 monitoring also found that the percentage of the reproductive population with buds (64%) was greater when compared to 2011 (11%), but lower when compared to 2017 (76%). Similarly, a greater percentage of the reproductive population showed fruits in 2018 (69%) compared to 2017 (48%), but not compared to 2011 (96%).

In 2011 and 2017, approximately 47% and 50% of the live *R. brevis* population was respectively assessed as reproductive compared 59% in 2018. This equated to 716 individuals in 2011, 708 individuals in 2017 and 826 individuals in 2018. The annual monitoring is usually completed earlier in the year (June - July), and therefore a greater number of individuals may have been in flower at the time of the 2018 monitoring event (September).

4.3 DEATH AND SEEDLING RECRUITMENT

Figure 10 shows the percentage of the monitored *R. brevis* population in each life stage (dead, reproductive, vegetative, juvenile or seedling) for the 2010 (baseline), 2017 and 2018 monitoring events. A total of 19 seedlings were located across all transects, and were considered to have emerged between 2017 and 2018. A cumulative total of 17 individuals had died across all transects between the 2017 and the 2018 monitoring events, representing a mortality rate of 1.2% based on the live population size as of 2017. The largest number of deaths were recorded in T10 (six deaths), whilst between zero and three deaths were observed in all other transects. Of those plants that died between 2017 and 2018, 24% (4 plants) were previously assessed as near death during the 2017 monitoring event, three of which were due other trees crushing the plants.

Fewer deaths were recorded between 2018 and 2017, compared with the 20 deaths recorded between the 2016 and 2017 monitoring events. In contrast, nine deaths were recorded during the 2011 monitoring event, which was the first year of observable changes since monitoring began in 2010.

There has been a consistent decline in total live individuals monitored since 2013 (Figure 5); however, with the exception of the period between 2015 and 2016, this has been by less than 1.5% per year. To assess the potential linkage between this decline and mining activities, the total live population results from monitored transects were grouped based on distance from operations (Figure 9). This exercise compared total live population numbers for transects within 500 meters of mining activities with those greater than 500 meters from mining activities, as illustrated in Figure 11. Total live population in transects located within 500 meters of the W1 and W2 pit mining activities decreased by 15.4% between 2010 and 2018, with 78% of those fatalities occurring in a single transect (T10, Figure 10). In contrast, the live population in transects located within 500 m of the W3 pit decreased by 1.7% between 2010 and 2018, and the live population in transects located greater than 500 m from operations decreased by 6.2% over the same period. Across all transects, the average proportion of individuals assessed as dead in 2018 was 7.6%.

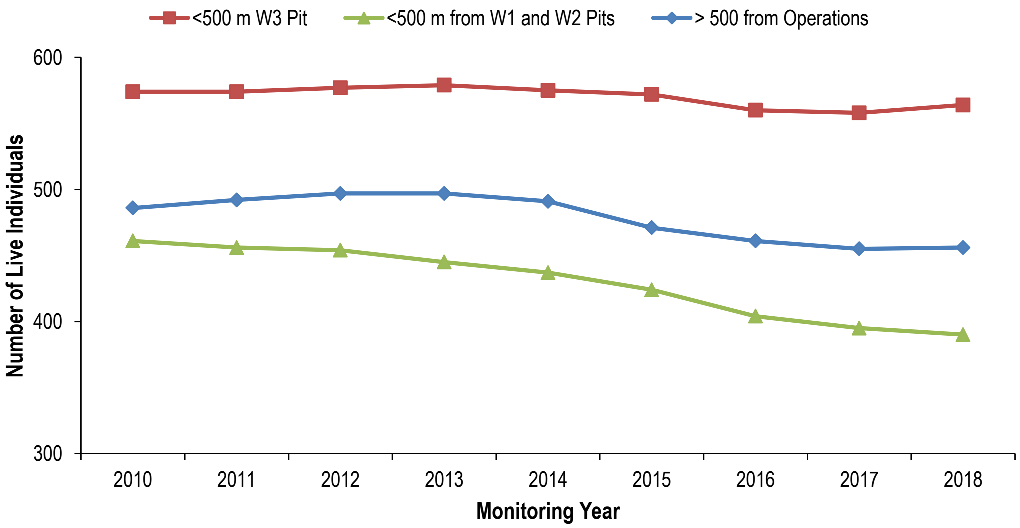

Figure 9: Live *R. brevis* Population by Proximity to Mining Activities

Whilst these comparisons highlight that the populations within 500 m of the W1 and W2 pit activities declined more substantially between 2010 and 2018 compared with populations adjacent to pit W3, they also highlight concomitant decline in populations located greater than 500 m from pit activities. In relative terms the decline observed in those distal transects (6.2%) was over three times the decline observed in transects adjacent to pit W3 (1.7%), also noting that 12 of the 19 seedlings located in 2018 were found in transects nearby pit W3 (Figure 11). Five of the newly recorded seedlings were in transects nearby pits W1 and W2, and two were in transects located further than 500 m from pit activities. Again, the data do not demonstrate a negative impact of mining activity upon seedling recruitment.

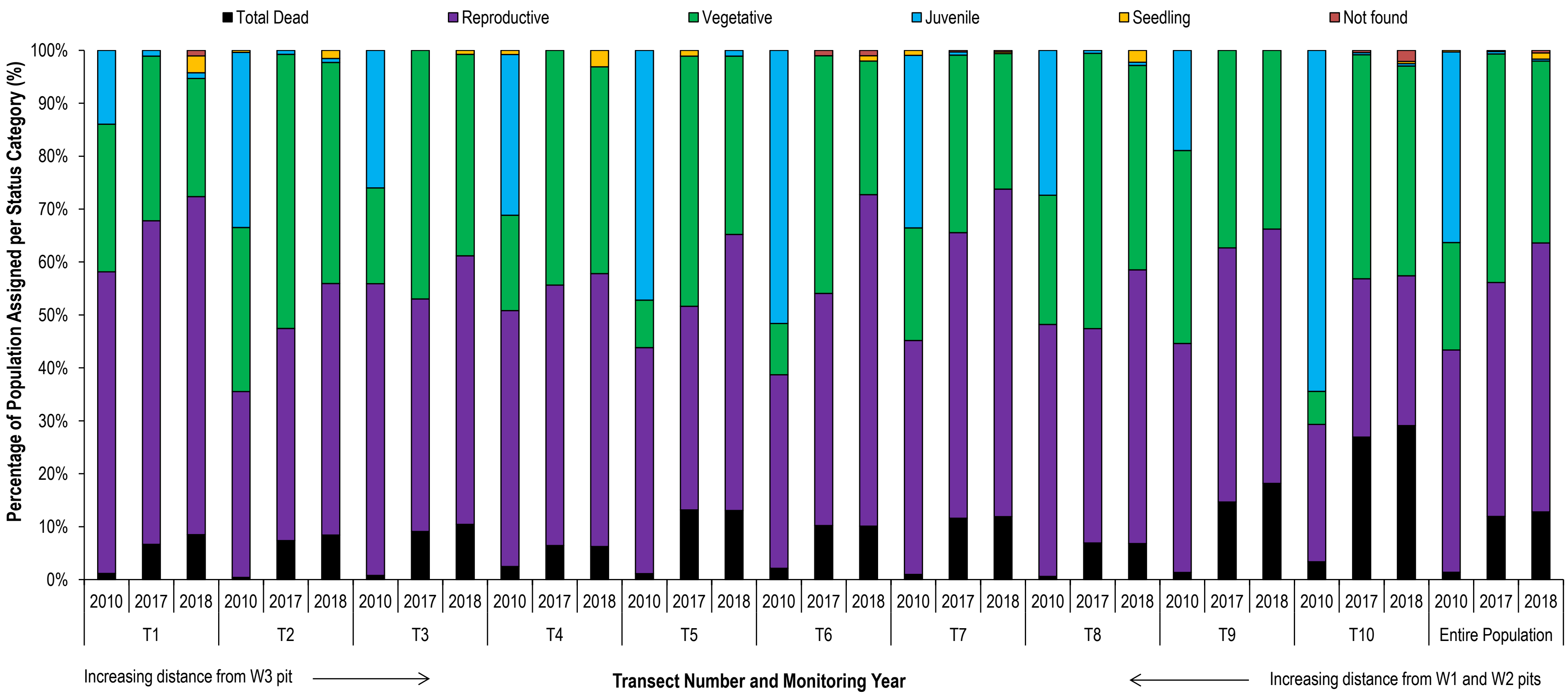

Figure 10: Percentage of Monitored Plants in Each Life Stage During the 2010, 2017 and 2018 Monitoring Events

Figure 11: Monitoring Transect Locations Grouped by Proximity to Mining Activity

To further explore the potential connection between *R. Brevis* mortality and pit activity , the live population size for monitoring plots within 500 m of W1/W2 and W3/W5 pits were plotted against the respective pit volume movement data (Section 3.2), as presented in Figure 12 and Figure 13. These comparisons both demonstrate that there is no clear relationship between the level of mining activity, as approximated by pit material movements, and the decline in live *R. Brevis* numbers.

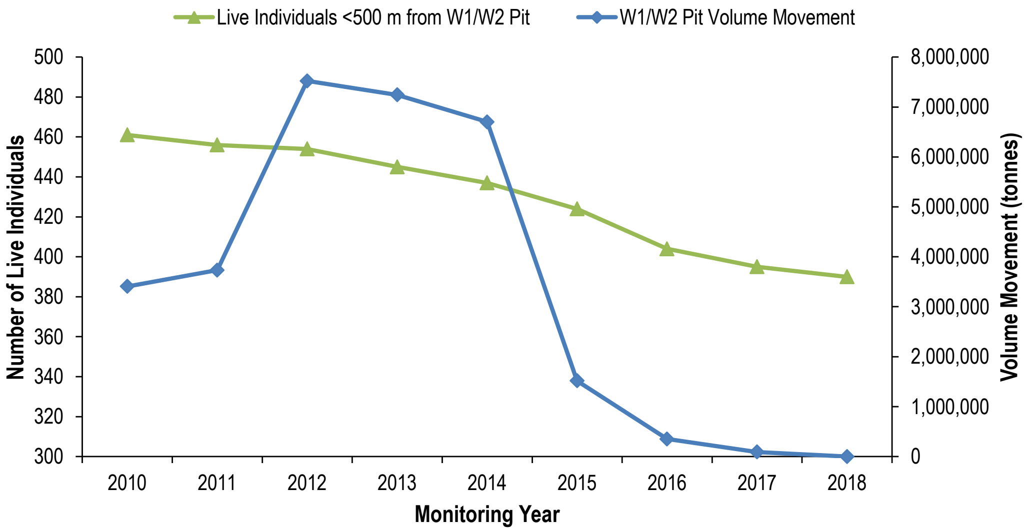

Figure 12: Live *R. Brevis* Population <500 m From W1/W2 Pits Versus W1/W2 Pit Volume Movement

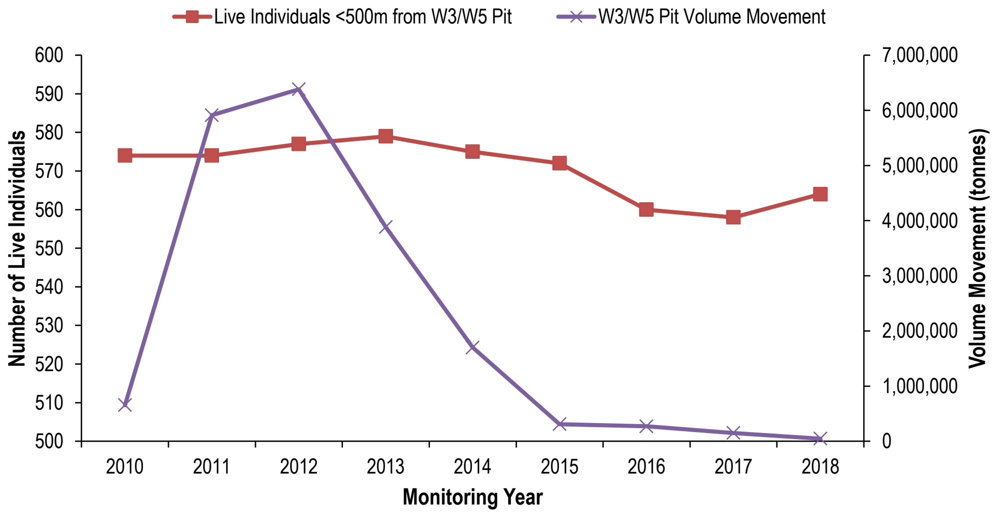

Figure 13: Live *R. Brevis* Population <500 m From W3/W5 Pits Versus W3/W5 Pit Volume Movement

5. DISCUSSION

5.1 OVERALL RESULTS

The results of the 2018 monitoring indicate that the *Ricinocarpos brevis* population at Windarling is in a generally healthy condition, similar to that recorded during 2017 and in 2011, when condition monitoring was first conducted. Condition assessments on selected individuals indicated an average live foliage cover of 80.3% during 2018 (81.2% in 2017 and 80% in 2011). Whilst statistical analysis determined that there was a significant change in overall population condition between 2018 and 2017, the associated decline in condition was minor (1.3%). Additionally, the statistical analysis determined that there was no evidence for a significant change in overall population condition in 2018, relative to the results from the 2011 baseline monitoring event. Given the 2018 monitoring found the *R. brevis* population to be in similar overall condition to 2011, the results suggest mining activities are not currently having a negative impact on the condition of live individuals within the population at Windarling.

The total live population increased by two individuals between 2017 and 2018 monitoring events, the first year-on-year increase recorded since 2012. This compares with relatively minor but consistent decreases in live numbers between 2010 and 2014 (decreased by 14 over four years) and a more substantial decrease of 79 individuals between 2014 and 2016. Nineteen seedlings were located during the 2018 monitoring event, marking a significant increase in recruitment versus an average of three seedlings per year over the period between 2010 and 2017.

The 17 fatalities reported from the 2018 monitoring event was similar to the 20 fatalities reported in 2017, despite the region receiving circum-average rainfall between January and December 2017. It should be noted that in the twelve months preceding the 2018 monitoring event (September 2017 – August 2018), Windarling received 243 mm total rainfall versus the long-term average (2010 and 2017) of 279 mm. Furthermore, rainfall between March and May 2018 (13 mm) was significantly lower than average (69 mm, 83% lower), which may have placed the population as a whole under water stress in the lead up to the 2018 monitoring event. As previously discussed (Cliffs 2017), the combination of lower-than average total rainfall and the uneven distribution of the rainfall received prior to monitoring is likely to have impeded plant survival, compared with periods with consistent rainfall throughout the year (e.g. 2012 and 2013).

The observation of fruits and seedling emergence in almost all years of monitoring indicates that the population is reproductive and, although the long-term recruitment rate is low, seedling emergence increased by a factor of five in the period preceding the 2018 monitoring relative to the long-term average. Research of *R. brevis* conducted at Windarling has indicated that seed can remain dormant in the soil for a number of years before germinating during favourable conditions (BGPA 2017). Consequently, there is potential for sporadic 'burst' germination events to occur in the population if natural environmental conditions are conducive. Windarling received 63 mm of rainfall during October and November 2018, the period leading up to the 2018 seedling searches. This represents approximately twice the long-term average (2005-2017) of 33 mm for these months, and may have contributed to the increased recorded seedling emergence.

The current results do not clearly demonstrate that the health of the *R. brevis* population at Windarling has been affected by nearby mining activities. Whilst the results of the 2017 and 2018 monitoring events indicate a higher than expected level of fatality in the monitoring transects located closest to pits W1 and W2, no corresponding trend was observed for transects nearby pit W3. Of the nineteen seedlings newly located in 2018, only two were in transects located more than 500 m from pits, suggesting that mining activities are not adversely affecting seedling recruitment. Comparisons between levels of mining activity and live population size did not illustrate a clear connection between the intensity of operational activity and the decline in live population size at these locations. It should also be noted that mining ceased in W1 pit in March 2017 and there has been minimal activity in W2 pit since 2014 (Section 3.2), suggesting that impacts from mining (e.g. dust emission) are unlikely to be connected with the observed live population decline in the nearby transects. Furthermore, as discussed in previous years (Cliffs 2017 and references therein), variable rainfall and grazing are also factors than can influence plant mortality.

Continued monitoring on an annual basis will likely provide further insight into the population dynamics of the *R. brevis* population at Windarling, as well as identifying the value of investigating the higher than average rate of fatality in monitoring transects closest to pits W1 and W2.

5.2 COMPARISON OF RESULTS AGAINST TRIGGER CRITERIA

The Yilgarn Operations Flora and Vegetation Management Plan (2016a) outlines trigger criteria that require further reporting and contingency actions. The following section compares the results of the 2018 monitoring against the relevant trigger criteria.

1. <u>Annual monitoring indicates a decline of greater than 15% in plant condition relative to the previous year; and rainfall is >150mm between annual sampling dates (i.e. the change is unlikely to be a result of drought conditions):</u>

The 2018 monitoring found a statistically significant, but relatively minor decline in average plant condition (80.3 % in 2018 versus 81.2% in 2017), as discussed in Section 4.1.

2. <u>Annual monitoring indicates a mortality of greater than 10% of the sampled population since the previous year and rainfall is >150 mm between annual sampling dates:</u>

Mortality was measured at 1.2% based on live population results from the 2017 and 2018 monitoring events, as discussed in Section 4.3.

3. <u>Annual monitoring indicates a consistent pattern of decline in population numbers over a longer time scale (2+ years):</u>

There has been a consistent decline in live population since 2013 (Figure 5); however, with the exception of the 2015 and 2016 monitoring, this has been by less than 1.5% per year. The majority of mortality recorded over the years has not been attributed to mining activities, but rather seasonal conditions and grazing by (suspected) native fauna, as previously reported in Cliffs (2014, 2015 and 2016b). Year-on-year trends suggest that the population has begun to stabilise, and the live population size increased by two individuals in 2018 versus 2017 due to improved seedling recruitment.

4. <u>Annual monitoring indicates a spatial pattern of decreasing plant condition and/or higher mortality that may be related to proximity to mining operations:</u>

The current results do not show a clear spatial pattern relating plant mortality and proximity to mining activities at Windarling. Whilst comparisons of live population sizes (2018 versus 2011 baseline) within transects show a greater number of fatalities within 500 m of the W1 and W2 pits, relative to those transects situated away (>500 m) from pits, the relative fatality rate of plants located nearby (<500 m) to the W3 pit was substantially lower than those situated away from any pit (as discussed in Section 4.3). Further investigation of potential connections between the level of mining activity (approximated by pit material movement) and population decline did not identify a clear relationship between activities and the populations located closest to the pits. As noted in previous reports (Cliffs 2017), it is suggested that the plant deaths are attributable to seasonal conditions and grazing by (suspected) native fauna as opposed to mining activities.

5. <u>Any direct effect on Rare Flora occurs as a result of mining activities e.g. unauthorised ground disturbance, fire:</u>

No direct effect on *R. brevis* has occurred as a result of mining activities.

6. <u>Any significant short term (i.e. < 1 year) decline in Rare Flora is detected at any time:</u>

No significant short term decline has been identified in the *R. brevis* live population size, which increased by two individuals between the 2017 and 2018 monitoring events (Table 2).

6. REFERENCES

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Attachment 10 – Windarling W1 and W2 Flora Monitoring Report

Yilgarn Iron Ore Project

2018 WINDARLING W1 AND W2 FLORA MONITORING

Proponent:	Yilgarn Iron Pty Ltd
Address:	1 Sleat Road, Applecross, WA 6153
Postal Address:	Locked Bag 3, Canning Bridge LPO, Applecross, WA 6153
Corporate contact:	Tim Berryman
Phone:	+61 8 9329 3713
	timothy.berryman@mrl.com.au

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1 Introduction

In August 2018 Mineral Resources Limited (MRL) acquired Cliffs Asia Pacific Iron Ore Pty Ltd.'s (Cliffs) Yilgarn Operations. This included the iron ore operations at the Koolyanobbing Range, Mt Jackson Range, Windarling Range and Deception, ore processing at Koolyanobbing, and the road and rail transport between these operations and the Port of Esperance where the processed ore is exported to international customers.

MRL continues to the implement the Flora and Vegetation Management Plan developed by Cliffs in accordance with Ministerial Statement 982. The Management Plan includes a monitoring programme developed to assess the condition and health of the Threatened flora species *Ricinocarpos brevis* and the condition of vegetation as defined by Keighery (1994) within 100m of the Windarling W1 and W2 open cut mine pits.

This report documents the results of the 2018 monitoring and compares them against the 2010 (initial monitoring) and 2016 and 2017 (previous years') monitoring results.

1.1 Overview of mining activities at W1 and W2

Mining above the water table commenced in W2 pit in 2004. Mining below the groundwater table began in 2009 and was completed in 2014. Clearing of the western part of the W1 Pit began in November 2011 and extended eastwards from 2012. Mining began in the western section of the W1 Pit in 2012 and in the eastern section during 2013. Backfilling of the W2 Pit commenced in 2014 and is ongoing as required. Mining was carried out in W1 on an ad hoc basis throughout 2016 and 2017 but has now ceased. Backfilling of the western section of W1 with waste from the W10 deposit has occurred from September 2018.

2 Methodology

2.1 Historical Monitoring

In 2010, 30 20m x 20m plots were established to conduct monitoring based on the following classifications:

- 10 control sites (over 200 metres from mining influences; labelled C1-C10)
- 10 near sites (between 70-120 metres from W2 Pit edge; labelled I1-I10) and
- 10 very near sites (between 20-70 metres from W2 Pit edge; labelled P1-P10).

Where possible, sites were selected so that they contained the Threatened Flora species *Ricinocarpos brevis.*

In 2011, the monitoring intensity was reduced to five plots in each classification (control, near or very near to W2 Pit edge). This reduction in monitoring plots was considered to be more time efficient whilst still providing reliable data.

In 2012, the 15 sites monitored in 2011 were revisited. Three of the sites (P1, I4 and I5) had been cleared for development of the W1 East mine pit. Three of the plots established in 2010, but not monitored in 2011, were selected to replace the cleared plots. These were I1, I7 and P7. The locations of these plots (including the cleared plots) as well as the W2 and W1 mine pits are shown in Figure 2.1

Since commencement of mining of the W1 pit, plots previously located 100-200m of the pit edge are now within 100m of the pit edge. As such, the '100-200m from pit edge' label has become redundant. From 2013, the plots have been combined and considered 'near pit', with the monitoring comparing 'near pit' and control plot results.

2.2 2018 Monitoring

The 2018 monitoring survey was conducted on the 6th and 7th of September 2018 and involved revisiting the 15 plots monitored in 2017.

2.2.1 Vegetation Condition Monitoring

At each plot, a photographic record was taken from the NW corner. The vegetation condition was evaluated using the Keighery (1994) scale (Table 2.1).

Table 2.1: Summary of Vegetation Condition Scale as developed by Keighery (1994)

Code	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered; obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as "parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

2.2.2 Individual Plant Monitoring

Within each plot, up to 14 individual plants previously selected for monitoring in 2010 - 2017 were revisited and monitored. Each individual was given a condition and dust rating using the scales outlined in Table 2.2 and Table 2.3.

Table 2.2: Condition rating for selected individual plants

Rating	Description
Healthy	No obvious signs of plant distress or negative impacts
Slightly Stressed	Small health impacts noticeable (i.e. slight drying out of leaves, yellowing of leaves, individual branches dead)
Stressed	Moderate health impacts noticeable (i.e. significant drying out of leaves, multiple branches showing yellowing of leaves, individual branches dead)
Very Stressed	Plant severely impacted. Appears to be on the verge of dying, large portions affected by negative health indicators
Dead	Plant is dead. Record timeframe (i.e. less than 6 months, 6 months – 1 year, greater than 1 year)

Table 2.3: Dust rating for selected individual plants

Rating	Description
No Dust	Plant does not have any level of dust covering, above what is normal for native plants in the region
Slight Dust Covering	Plant has slight dust covering on leaves (Less than 25% of individual covered in dust)
Moderate Dust Covering	Plant has moderate dust covering of leaves and stem/branches (26-50% of individual covered in dust)
Heavy Dust Covering	Plant has heavy dust covering of leaves and stem/branches (51-75% of individual covered in dust)

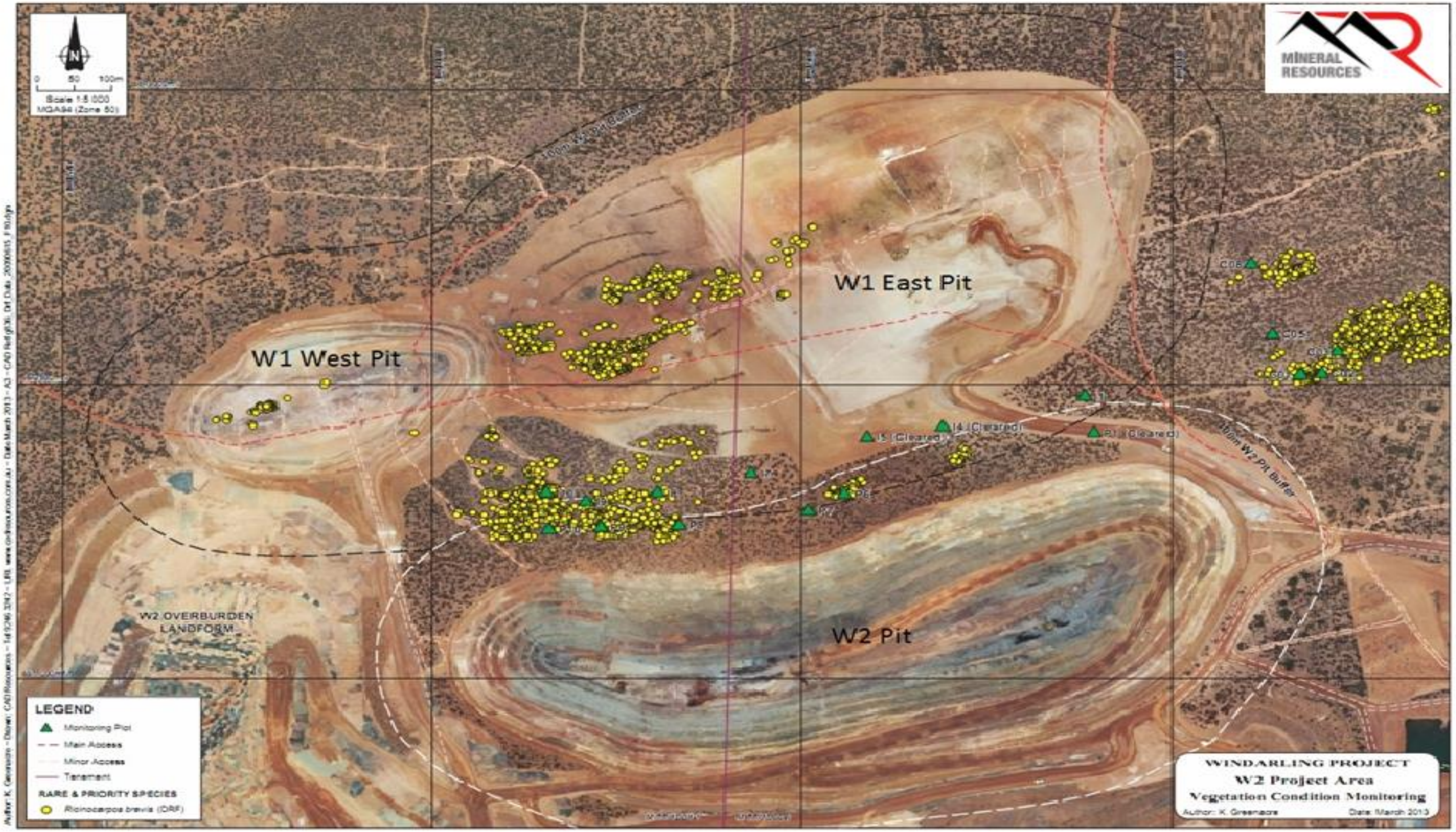

Figure 2.1: Location of monitoring plots and the W1 and W2 mine pits.

2.2.3 Ricinocarpos brevis Monitoring

A total of 16 *Ricinocarpos brevis* individuals were selected within plots (as part of Individual Plant Monitoring) and their health and dust levels assessed using the methods outlined in Section **Error! Reference source not found.**. These individuals were also given a percentage score based on the total amount of live foliage present on the individual. *R. brevis* was monitored in the following plots:

- Controls: C1 and C3 (Four *R. brevis* plants monitored)
- Near Pit: I8, I9, I10, P6, P9 and P10 (11 *R. brevis* individuals monitored)

Annual monitoring of *Ricinocarpos brevis* was carried out by MBS Environmental, MBS(2019) and involved 10 transects up to 100m long, established across the Windarling Range, two of which are in close proximity to W2 Pit (Figure 2.2). *R. brevis* individuals occurring within the first 30m of transects 9 and 10 (Figure 2.2) have been treated as occurring near the pit edge. Transect 8 (Figure 2.2) in the annual *Ricinocarpos* brevis monitoring overlaps the control plots established for this W1 and W2 Flora Monitoring program. All *R. brevis* occurring within transect 8 have been treated as control individuals. Individuals within these transects were randomly selected to be given a percentage score based on the total amount of live foliage present on the individual.

Figure 2.2: : Location of transects in annual Ricinocarpos brevis monitoring.

2.3 Rainfall

Rainfall is an important limiting factor in the health of flora and vegetation. Western Botanical (2008) found that drought, changes in microclimates increasing exposure to heat and wind, and dust blocking stomata can all contribute to the decline in health or death of vegetation. For this reason, it is important to consider the amount of rainfall received prior to monitoring when comparing the health of vegetation from year to year. Rainfall data was collected at MRL's weather station located on Windarling Range, registered with the Bureau of Meteorology (BoM). The weather station was established in 2004 and MRL has a dataset spanning 14 years.

The total rainfall recorded at the Windarling weather station prior to the 2018 monitoring (August 2017 – August 2018) is presented in Figure 2.3, along with total rainfall recorded prior to previous monitoring events and the 2005-2018 average annual rainfall (BoM 2018).

A total of 251.9mm of rainfall fell at Windarling in the 12 months prior to the 2018 monitoring, less than the 273.9mm recorded prior to the 2017 monitoring yet greater than the 174.1mm recorded prior to the initial monitoring in 2010. The rainfall received prior to the 2018 monitoring was well below the 2005-2018 average of 281.8mm (Figure 2.3).

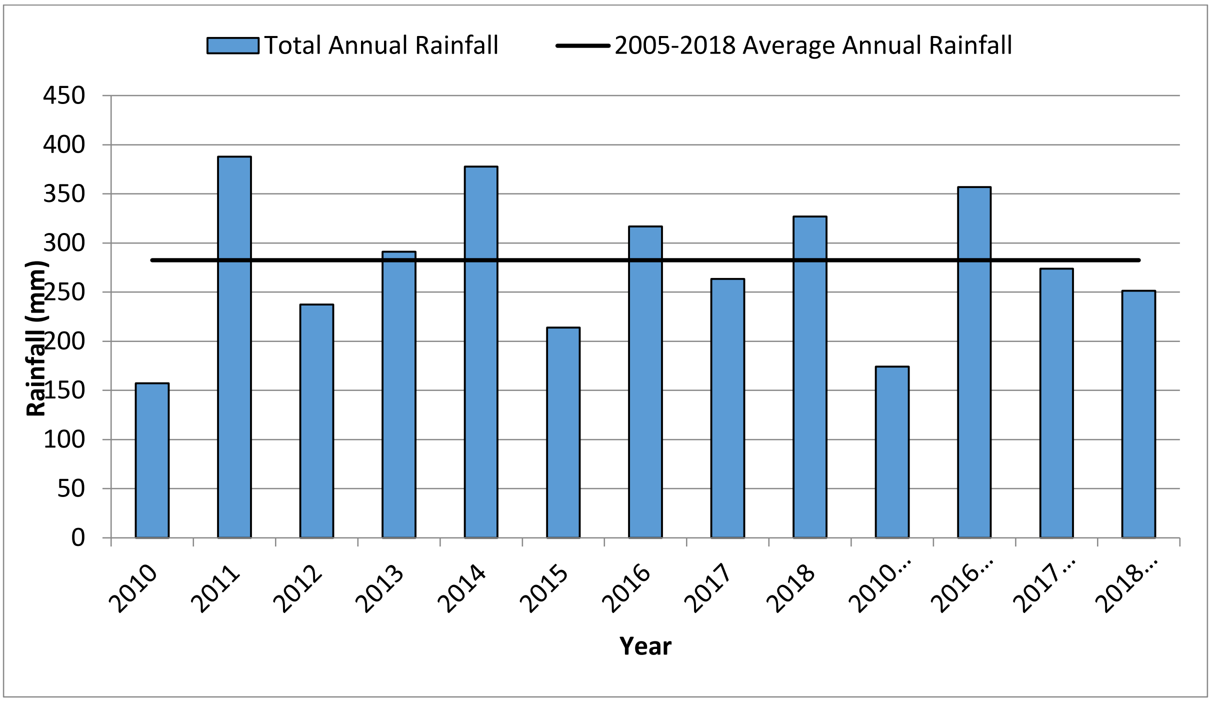

Figure 2.3: Total annual rainfall and 2010-2018 vs average annual rainfall at Windarling (BoM 2018).

Figure 2.4 shows the total monthly rainfall recorded at Windarling for 2010 (initial monitoring), 2016, 2017 (previous years monitoring) and 2018 (current year monitoring). The 2005-2018 monthly average rainfall is also shown (BoM 2018). Almost half (43%) of the total rainfall received in the months prior to the 2018 monitoring fell during January and February 2018. There were 6 months (November 2017, January 2018 , February 2018, June 2018, July 2018 and August 2018) recorded above average rainfall prior to the 2018 monitoring (Figure 2.4).

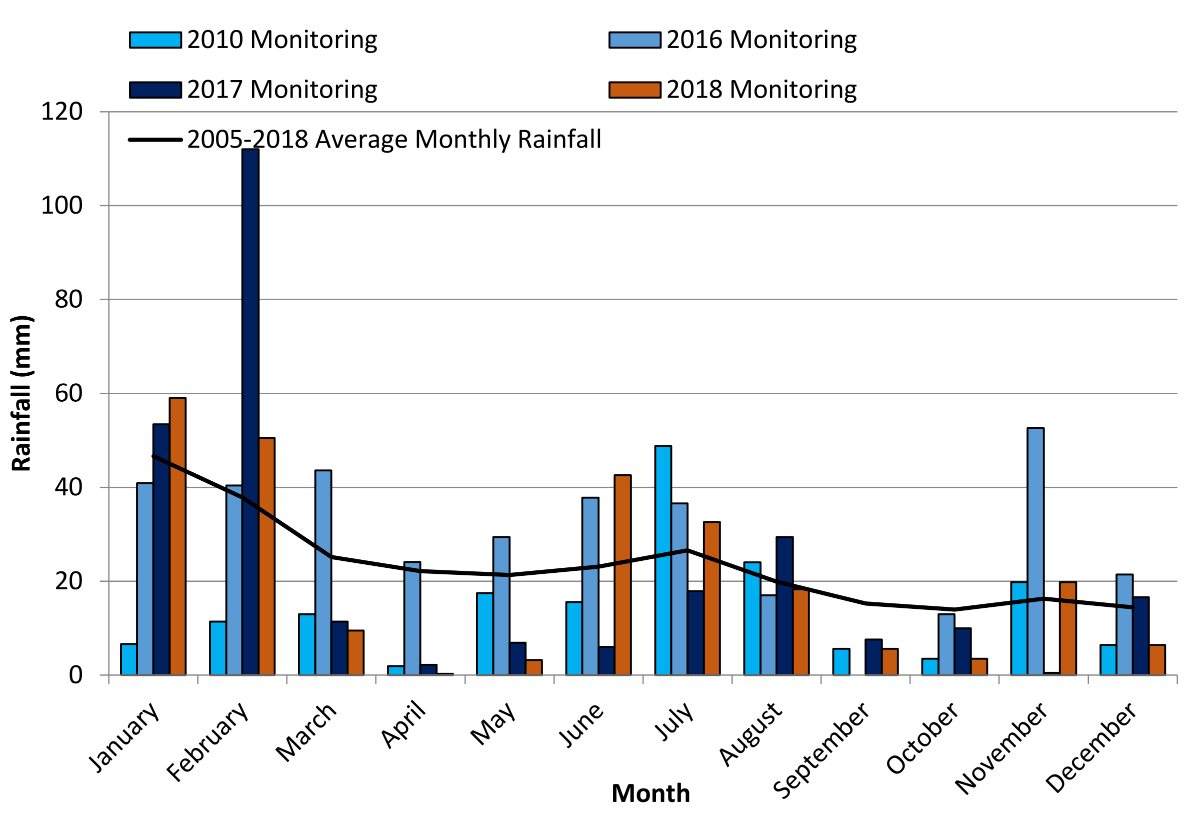

Figure 2.4: Total monthly rainfall (2010, 2016,2017 and 2018) and 2005-2018 monthly average at Windarling (BoM 2018).

3 Results

3.1 Vegetation Condition

The results of the 2010 (initial monitoring), 2016, 2017 (previous years monitoring) and 2018 monitoring vegetation condition are shown in Table 3.1. The 2018 monitoring found all plots to be in healthy condition, ranked in either the ‘Excellent’ or ‘Very Good’ category, as defined by Keighery (1994).

All control plots were recorded in ‘Excellent’ condition in 2018. Seven plots located near pit recorded a slight decrease between 2017 and 2018, while the remaining three recorded a slight increase in condition. When compared to the 2010 (initial) monitoring results, the 2018 monitoring found vegetation condition at 4 plots located near the pit had slightly decreased, two plots had increased in condition and the remainder had remained stable. (Table 3.1).

Table 3.1 Results of the 2010, 2016, 2017 and 2018 Vegetation Condition Monitoring

Type	Plot	2010	2016	2017	2018	Change 2017-2018	Change 2010-2018
Control	C01	Excellent	Excellent	Excellent	Excellent	-	-
Control	C02	Excellent	Excellent	Excellent	Excellent	-	-
Control	C03	Excellent	Excellent	Excellent	Excellent	-	-
Control	C05	Excellent	Excellent	Excellent	Excellent	-	-
Control	C08	Excellent	Excellent	Excellent	Excellent	-	-
Near Pit	I1	Very Good	Excellent - Very Good	Excellent - Very Good	Very Good	Slight decrease	Slight decrease
Near Pit	I7	Very Good	Excellent - Very Good	Excellent - Very Good	Very Good	Slight decrease	-
Near Pit	I8	Excellent	Excellent	Excellent - Very Good	Very Good	Slight decrease	Slight decrease
Near Pit	I9	Excellent	Excellent	Excellent	Very Good	Slight decrease	Slight decrease
Near Pit	I10	Excellent	Excellent	Excellent - Very Good	Excellent	Slight increase	-
Near Pit	P6	Very Good	Excellent	Excellent	Very Good	Slight decrease	-
Near Pit	P7	Very Good	Excellent	Excellent	Very Good	Slight decrease	-
Near Pit	P8	Excellent	Excellent	Excellent	Very Good	Slight decrease	Slight decrease
Near Pit	P9	Very Good	Excellent	Excellent - Very Good	Excellent	Slight increase	Slight increase
Near Pit	P10	Very Good	Excellent	Excellent - Very Good	Excellent	Slight increase	Slight increase

3.2 Individual Plant Monitoring

3.2.1 Condition

The results of the individual plant condition monitoring are shown in Figure 3.1. The 2018 monitoring found individuals near the pits decreased slightly in health since the 2017 monitoring and there was a 5.6% decrease of 'Healthy' individuals into the 'Slightly Stressed' category. There have been no new deaths in the monitored individuals and overall there has been no increase in the number of individuals in the lower condition categories. Individuals within the control plots have shown an improvement in health since the 2017 monitoring. The percentage of individuals in the 'Healthy' category increased from approximately 63% to 77%. There were no individuals recorded in the 'Stressed' or 'Very Stressed' categories within the control plots this monitoring period.

The 2018 monitoring found individuals in both the control and near pit plots were in a healthier condition than when monitoring began in 2010. Approximately 61% of individuals in the control plots were considered 'Healthy' during the 2010 monitoring, compared with 77% in 2018. For individuals in near pit plots, 45% were considered 'Healthy' in 2010, compared with 61% during 2018 (Figure 3.1).

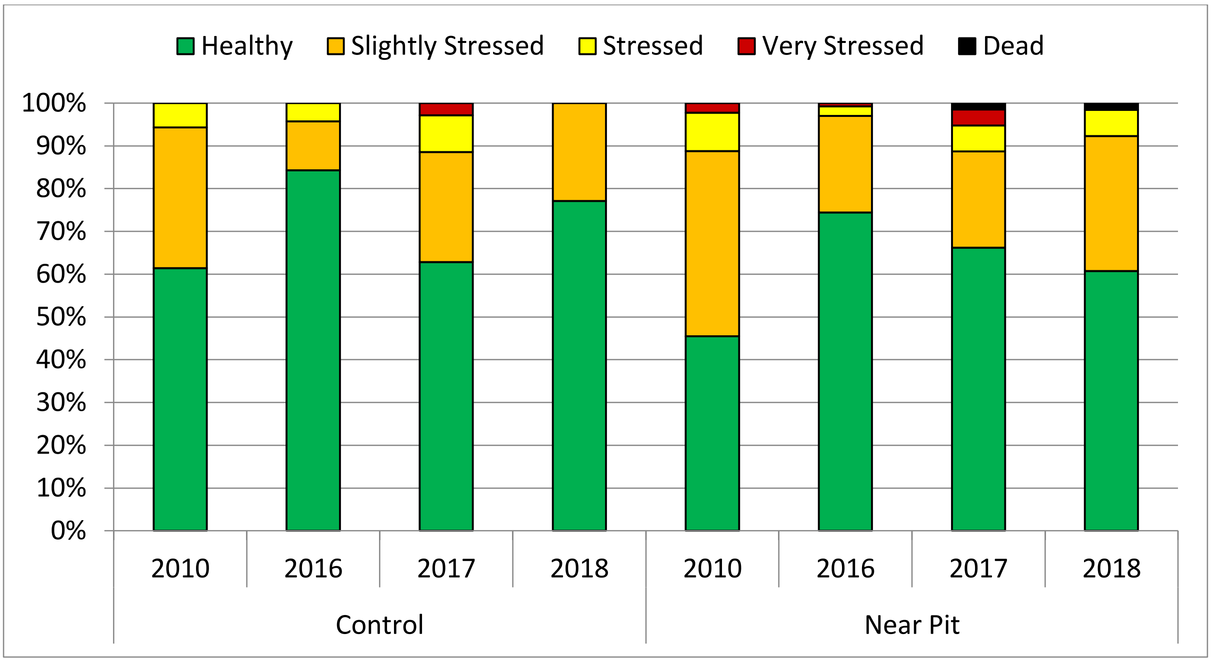

Figure 3.1: Condition rating of tagged individual plants monitored during 2010, 2016, 2017 and 2018.

3.2.2 Dust

The results of the individual plant dust monitoring are shown in Figure 3.2. Dust levels were proportionately correlated between control and near pit locations between 2017 and 2018. Since monitoring began in 2010, dust levels have decreased on individuals both in the control locations (from 55% with dust to 91% dust free) and near the pits (from 55% no dust to 89% dust free).

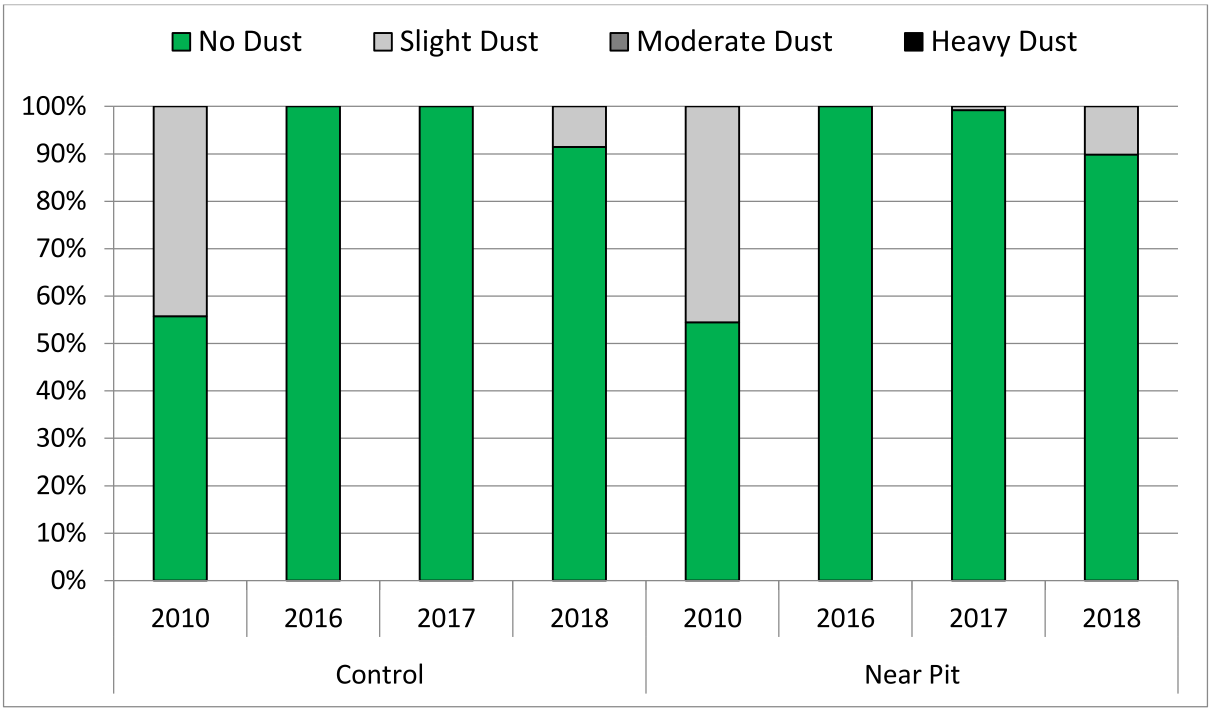

Figure 3.2: Dust rating of tagged individual plants monitored during 2010, 2016, 2017 and 2018

3.3 Ricinocarpos brevis Monitoring

The 2018 monitoring found the condition rating of *R. brevis* individuals remained unchanged in control locations and increased slightly in the near pit locations since the 2017 monitoring (Figure 3.3). All individuals within the control locations were recorded as 'Healthy' in 2017 and 2018; whilst individuals near the pit recorded approximately 83% 'Healthy' in 2017 compared with 75% 'in 2016.

Since monitoring began in 2010, the health of individuals has increased in both the control and near pit areas, although by a greater percentage in the control area (Figure 3.3).

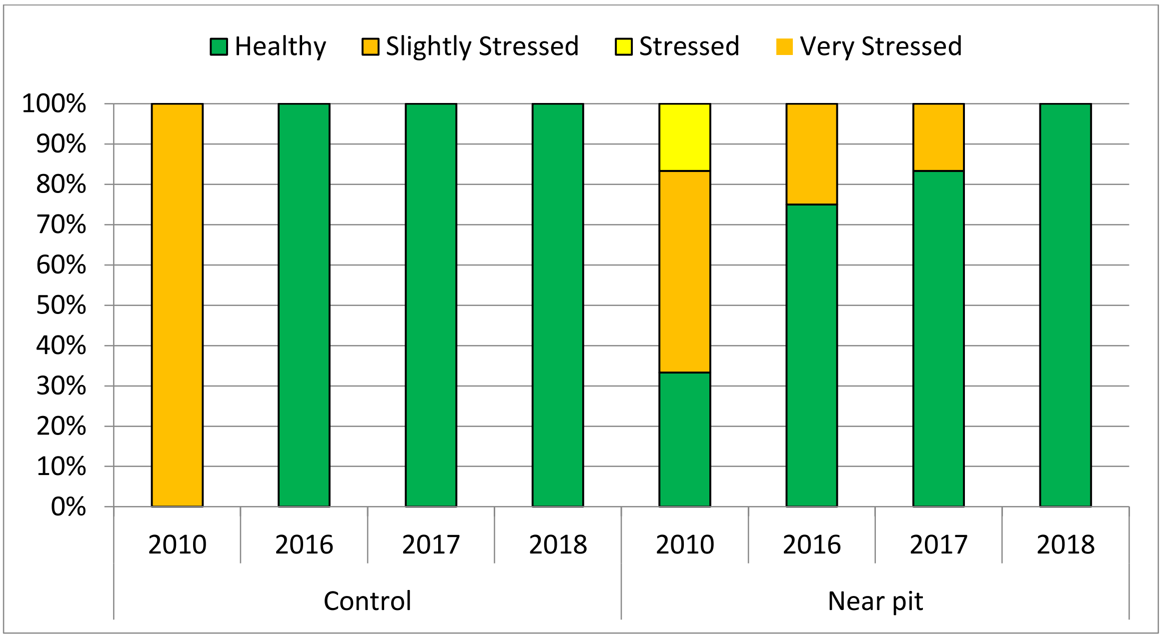

Figure 3.3: Condition rating of tagged Ricinocarpos brevis individuals in monitored plots during 2010, 2016,2017 and 2018.

Figure 3.4 presents the dust levels on *Ricinocarpos brevis* at both locations during 2010 (initial monitoring), 2016, 2017 (previous years monitoring) and 2018 monitoring. The *R. brevis* individuals in both near pit and control locations were recorded as dust free in 2017and 2018.

Since monitoring began in 2010 dust levels have decreased on individuals in both the control and near pit locations. Individuals within the control locations recorded 100% with 'Slight Dust' in 2010 compared with 100% dust free in 2017 and 2018; whilst individuals in near pit locations recorded 33% dust free in 2010 and 100% dust free in 2017 2018.

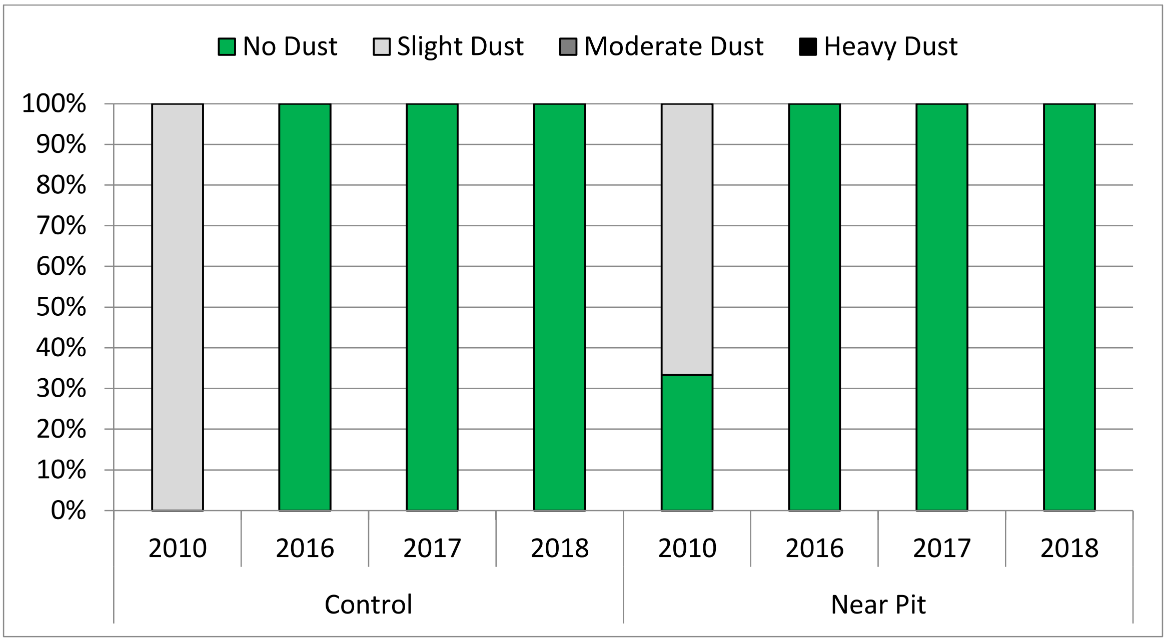

Figure 3.4: Dust rating of tagged Ricinocarpos brevis individuals in monitored plots during 2010, 2016, 2017 and 2018.

Figure 3.5 displays the percentage of individuals in each health category, based on percentage of live foliage per individual, for *Ricinocarpos brevis* at each location for 2010 (initial year), 2016, 2017 (previous years) and 2018 monitoring. This includes the *R. brevis* individuals tagged and monitored in the annual *Ricinocarpos brevis* monitoring (as outlined in Section **Error! Reference source not found.**). This data is not available for 2010 as *R. brevis* plants were not monitored for percentage of live foliage until 2011. The 2011 results have therefore been treated as baseline data.

The 2018 monitoring recorded an increase in the percentage of individuals in the highest category (Healthy, >75% live foliage) in the control locations (by 6%) while the near pit locations remained the same as in 2017. Individuals in the control location, having previously been recorded as stressed, were found to be recovering and were now in the slightly stressed category. Whereas a 5% decrease in condition was recorded for those near the pits in 2018 (Figure 3.5). Since the 2011 (baseline monitoring) the health of individuals in both the control locations and near pit locations has increased. The control location recorded 77% of individuals as 'Healthy' in 2011 as compared to 82% in 2018, whilst individuals near pit recorded 64% and 72% as 'Healthy' in 2011 and 2018 respectively.

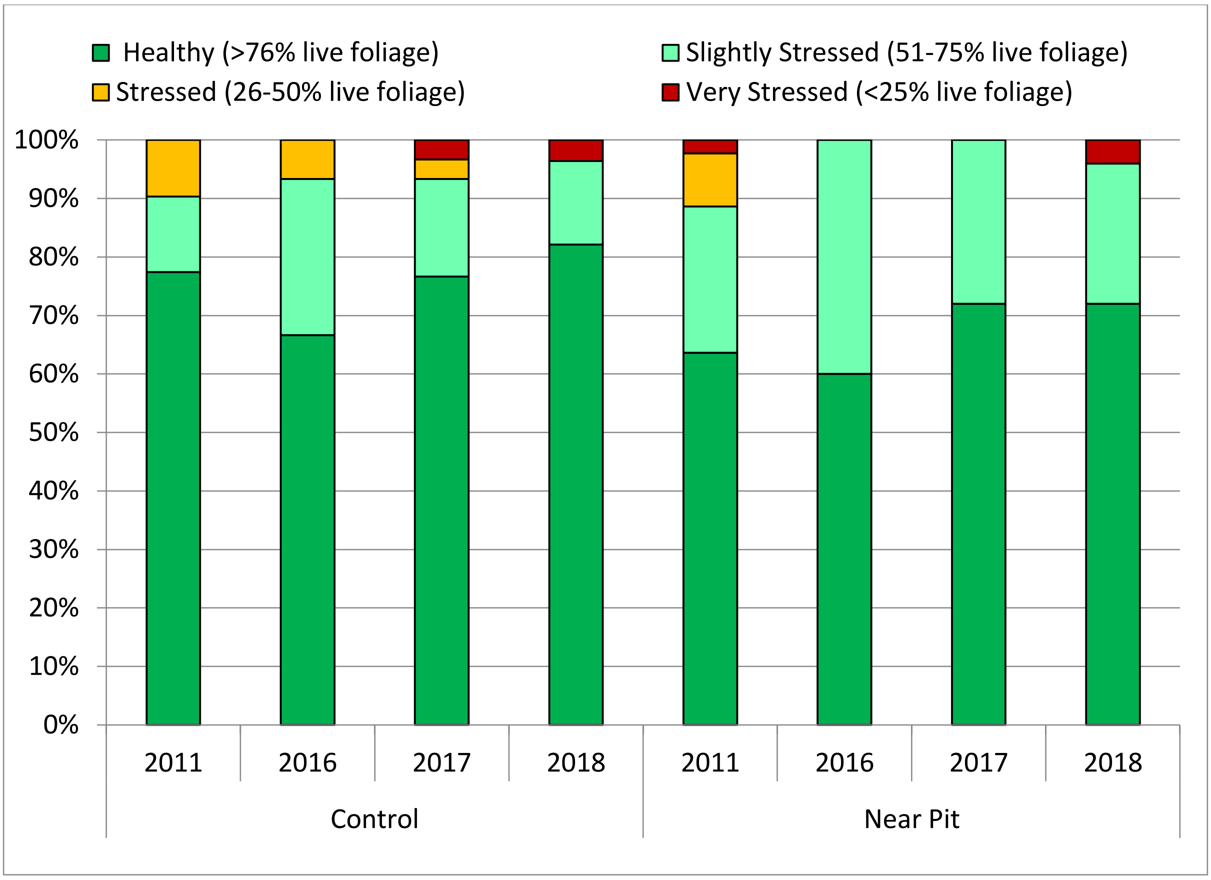

Figure 3.5: Percentage of R. brevis individuals in each health category (based on live foliage per individual) at each location for 2011, 2016 and 2017.

Note: this included individuals monitored during the annual monitoring.

4 Discussion and Conclusions

4.1 Vegetation Condition

The 2018 monitoring found the vegetation surrounding the pits to be healthy, ranked in either 'Excellent' or 'Very Good' condition. There were some slight decreases (6 of the 15 plots) between 2017 and 2018 in the condition of vegetation in plots located near the pits. 3 that increased in condition and 6 that recorded no change. This could be due to some grazing pressure from large herbivores when mining was scaled back at the Windarling range. Currently, there is no correlation between vegetation health and distance from mining, therefore the changes observed during the 2018 monitoring are not considered to be mining-related.

4.2 Individual Plant Condition

The tagged individuals within the control plots were healthier in 2018 than in 2017. Individuals near the pits showed a 5% decline within the highest health category, however showed signs of recovery within the lower categories with fewer numbers of individuals displaying signs that placed them in the very stressed category. Overall the vegetation monitored is considered to be in a healthy condition with no new deaths recorded. All locations have shown a marked increase in health since monitoring began in 2011. Therefore, it does not appear that activities within the pits are having a negative impact on the health of individual species adjacent to the pit.

Individuals in both the control and near pit locations recorded elevated dust levels in 2018. The increased dust loads can most likely be attributed extremely low rainfall in September and the backfilling operations occurring at W1 at the time of the monitoring. There is currently no correlation between dust levels and the health of individual plants.

4.3 *Ricinocarpos brevis* Condition

The tagged *R. brevis* individuals within monitored plots in near pit locations did not record any change in the number of individuals in the 'healthy' category in 2018, however some individuals decreased in condition to 'very stressed'. Control locations also recorded the same percentage of individuals within the 'very stressed' category (4%) which may suggest that plant stress could be attributed to natural factors such as the lack of spring rainfall and elevated daytime temperatures.

No dust was recorded on any individual in either location (near pit or control) during the 2018 monitoring. There is no apparent correlation between dust levels and health rankings for *R. brevis* individuals. Individuals in both the near pit and control locations were found to be in a healthier condition than when monitoring first began. Therefore, it does not appear that mining activities are having an impact on the *R. brevis* individuals adjacent to the pits.

This monitoring will be continued annually until backfilling into W1 and W2 pit is complete. It has been suggested that Chlorophyll Fluorescence measurements be taken while conducting the 2019 monitoring as this will enable us to physically quantify plant stress which will complement the visual assessment.

4.4 Comparison of Results against Trigger Criteria

The Flora and Vegetation Management Plan (2016) outlines trigger criteria that require further reporting and contingency actions. The following section compares the results of the 2018 monitoring against the relevant trigger criteria.

1. *Annual monitoring indicates a decline of greater than 15% in plant condition relative to the previous year; and rainfall is >150mm between annual sampling dates (i.e. the change is unlikely to be a result of drought conditions).*

   Annual monitoring indicates that plants other than in the reference sites (control plots) experienced a 6% decline in condition since the last monitoring period. Ricinocarpos brevis individuals have conversely seen a 16% improvement in health for monitored individuals in near pit plots. Therefore, this trigger criterion has not been met.

2. *Annual monitoring indicates a mortality of greater than 10% of the sampled population since the previous year and rainfall is >150mm between annual sampling dates.*

   Mortality in both near pit and control plots were stable when compared to the previous year. Control plots recorded no deaths while near pit locations saw 1.5% mortality rate in 2018 (2 individuals) and has remained the same when compared to the previous year. It is therefore concluded that this trigger criterion has not been met.

3. *Annual monitoring indicates a consistent pattern of decline in population numbers over a longer time scale (2+ years).*

   Annual monitoring does not indicate a consistent pattern of decline. Cumulative data from 2010 indicates that population has gone through phases of recovery as well as decline. Overall population is in a better condition than compared to 2010.

4. *Annual monitoring indicates a spatial pattern of decreasing plant condition and/or higher mortality that may be related to proximity to mining operations*.

   There is no correlation between mining activity and a spatial distribution of decreasing plant condition and mortality rates as given by McNemar's test statistic (See Appendix 1). The results show that there has been a statistically significant improvement in condition.

5. *Any direct effect on Rare Flora occurs as a result of MRL's activities e.g. unauthorised ground disturbance, fire.*

   No direct effect on the monitored R. brevis or the Windarling vegetation has occurred as a result of mining activities.

6. *Any significant short term (i.e. < 1 year) decline in Rare Flora is detected at any time.*

   No significant short term decline has been identified in the R. brevis or Windarling vegetation live population size.

5 References

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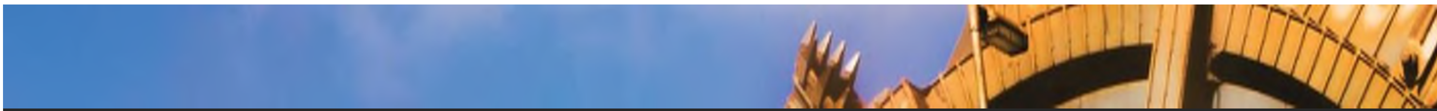
6 Appendix 1

	Year B		
Year A	Decreased Condition	Same Condition	Increased Condition
	6	44	20

Significance level, α:	95%
McNemar's test statistic:	7.009615385
p-value:	0.0081
Conclusion:	*There is a statistically significant change in condition (at the 95% level)*
Binomial probability:	0.0094
Conclusion:	*There is a statistically significant change in condition (at the 95% level)*

Figure 6.1: McNemar's Test Statistic for 95% confidence interval

Attachment 11 – Mt Jackson J1 Biodiversity Monitoring



Yilgarn Iron Ore Project

2018 J1 BIODIVERSITY MONITORING REPORT

Proponent:	Yilgarn Iron Pty Ltd
Address:	1 Sleat Road, Applecross, WA 6153
Postal Address:	Locked Bag 3, Canning Bridge LPO, Applecross, WA 6153
Corporate contact:	Tim Berryman
Phone:	+61 8 9329 3713
	timothy.berryman@mrl.com.au

Report Reference: ENV-TS-RP-0127

Rev No.	Author	Distribution	Date	Status
A	Terry Netto	N Smith	23-02-2019	Draft for Internal Review
O	Terry Netto	DWER	23-03-2019	Final

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Figures

Tables

1 Introduction

1.1 Background

In 2018 Mineral Resources Limited (MRL) acquired Cliffs Asia Pacific Iron Ore Pty Ltd.'s (Cliffs) Yilgarn Operations. This includes the mining of iron ore from open cut mines at the Koolyanobbing Range, Mt Jackson Range, Windarling Range and Deception, ore processing at Koolyanobbing, road and rail transport between these operations and the Port of Esperance where the processed ore is exported to international customers.

The Mt Jackson J1 Deposit mining project was approved in 2010, subject to the conditions prescribed by Ministerial Statement 843 under the *Environmental Protection Act 1986*. Condition 6-5 of Statement 843 required that Cliffs undertake monitoring for indirect impacts of mining on conservation significant vegetation and flora.

Condition 6-5 stated:

"For the purpose of meeting the requirements of Condition 6-6, the proponent shall monitor indirect impacts from activities undertaken in implementing the proposal, including dust and drainage/change in surface water flows, on the condition of conservation significant vegetation communities and flora species within the Biodiversity Areas delineated in Schedules 1 and 2 and Figure 6. This monitoring is to be carried out with the approval of the CEO on advice of the Department of Environment and Conservation."

In accordance with Condition 6-5 and with advice from the Department of Biodiversity Conservation and Attractions (DBCA, formerly the Department of Environment and Conservation), Cliffs developed a vegetation and flora monitoring program for the J1 mining operation (Cliffs 2012). This program was subsequently approved by the Chief Executive Officer (CEO) of the then Office of the Environmental Protection Authority (OEPA).

During September 2014, Cliffs' seven Ministerial Statements (including Statement 843) were consolidated into a single document - Ministerial Statement 982 (Minister for Environment and Heritage 2014). As a result of this consolidation, the condition requiring the specific aspects monitored under this J1 Biodiversity Monitoring Program (condition 6-5 of Statement 843) were removed. Condition 5-1 of Statement 982 requires the J1 Biodiversity Monitoring Program to continue to be implemented until a Flora and Vegetation Management Plan has been developed and approved by the CEO of the OEPA. The Flora and Vegetation Management Plan was approved by the OEPA in September 2016 and is currently being implemented.

1.2 Objectives and scope

The objective of the J1 Monitoring is to monitor for changes in vegetation and flora condition that may be attributable to mining operations (e.g. from elevated dust levels or changes in surface water flows/drainage regimes). This report presents the results of the 2018 monitoring, conducted in October, and compares them against the 2017 (previous year) and where possible, the 2012 (initial year) monitoring results.

2 Methodology

2.1 Plot establishment

During 2016, five 20 x 20m monitoring plots were established, with their locations chosen based on being within the dominant vegetation units around J1 (and the ability to also establish control plots within the same vegetation units), their presence within Biodiversity Areas, and where possible, to allow for the inclusion of Priority Flora species for individual monitoring. Each plot was marked with a metal stake in the ground at each corner. A unique plot identification number was attached to the stake positioned in the northwest corner of the plot. At each plot, the following information was recorded:

- Plot Identification Number
- Monitoring date
- Personnel conducting monitoring
- GPS location (GDA94) taken from northwest corner of plot
- Photographic record taken from northwest corner of plot
- Vegetation condition and
- Weed assessment.

Plots 09, 10, 14, 21, 23 and 24 established in 2012 (Cliffs 2012) were retained within the revised monitoring program. Table 2.1 shows the number of plots established within each vegetation unit and Figure 2.1 shows their location in relation to vegetation units and mining activities.

Table 2.1: Number of plots established in each Vegetation Unit

Vegetation Unit	Location	Number of Plots
EcW – *Eucalyptus corrugata* Woodland	Near mining	3
	Control	2
AeS – *Acacia effusifolia* Shrubland	Near mining	2
	Control	1
AmjS – *Acacia* sp. Mt Jackson Shrubland	Near mining	1
	Control	2

2.2 Monitoring

2.2.1 Vegetation Condition

The condition of the vegetation occurring within each plot was assessed using the classification scheme developed by Keighery (1994) and shown in Table 2.2.

Table 2.2: Vegetation Condition Scale as developed by Keighery (1994)

Code	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered; obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching 'Good' condition without intensive management. For example, disturbance to vegetation structure caused by frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as "parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

2.2.2 Flora Condition

Within each plot, up to 12 individuals were tagged for flora condition monitoring. The individuals selected included those within the upper, middle and lower stratums of the vegetation within the plot. Where possible the same species were selected in each plot to allow for comparisons and Priority Flora individuals were selected where present. Each individual monitored was identified with a pin flag marker adjacent to the individual and a unique identification number written on the pin flag. Each individual was then given a health and dust assessment based on the scales outlined in Table 2.3 and Table 2.4 respectively.

Table 2.3: Individual plant condition scale

Rating	Description
Healthy	76-100% of foliage alive. No obvious signs of plant distress or negative impact
Slightly Stressed	51-75% of foliage alive.
Stressed	26-50% of foliage alive.
Very Stressed	1-25% of foliage alive. Plant appears to be on the verge of dying.
Dead	0% of foliage alive. Plant is dead.

Table 2.4: Individual plant dust scale

Rating	Description
No Dust	0% of foliage dusty
Slight Dust	1-25% of foliage dusty
Moderate Dust	26-50% of foliage dusty
Heavy Dust	51-75% of foliage dusty
Very Heavy Dust	76-100% of foliage dusty

2.2.3 Weed Assessment

Where non-indigenous flora species were found in plots, their species name and approximate foliage cover of the 20m x 20m plot was recorded.

2.3 2018 Monitoring

The 2018 monitoring was conducted on the 19th of October 2018. The 11 plots monitored in 2017 were revisited and monitored following the same methods outlined in Section 2.2.

2.3.1 Chlorophyll Fluorescence Assessment

Index of Chlorophyll Fluorescence (Fv/Fm) was added as a monitoring parameter in 2017. Each individual that could be reached (i.e. tall trees were excluded) had an index of chlorophyll fluorescence (CF) measurement taken using a pocket PEA unit. Using information gained from CF measurements, samples may be screened effectively for particular types of stress factors which limit the photosynthetic performance of the individual (Hansatech 2006). A clip was attached to a live leaf of each individual, to dark adapt the phyllodes. An index of chlorophyll fluorescence was then measured with the PEA unit and recorded on the data sheet. The same process was carried out again in 2018.

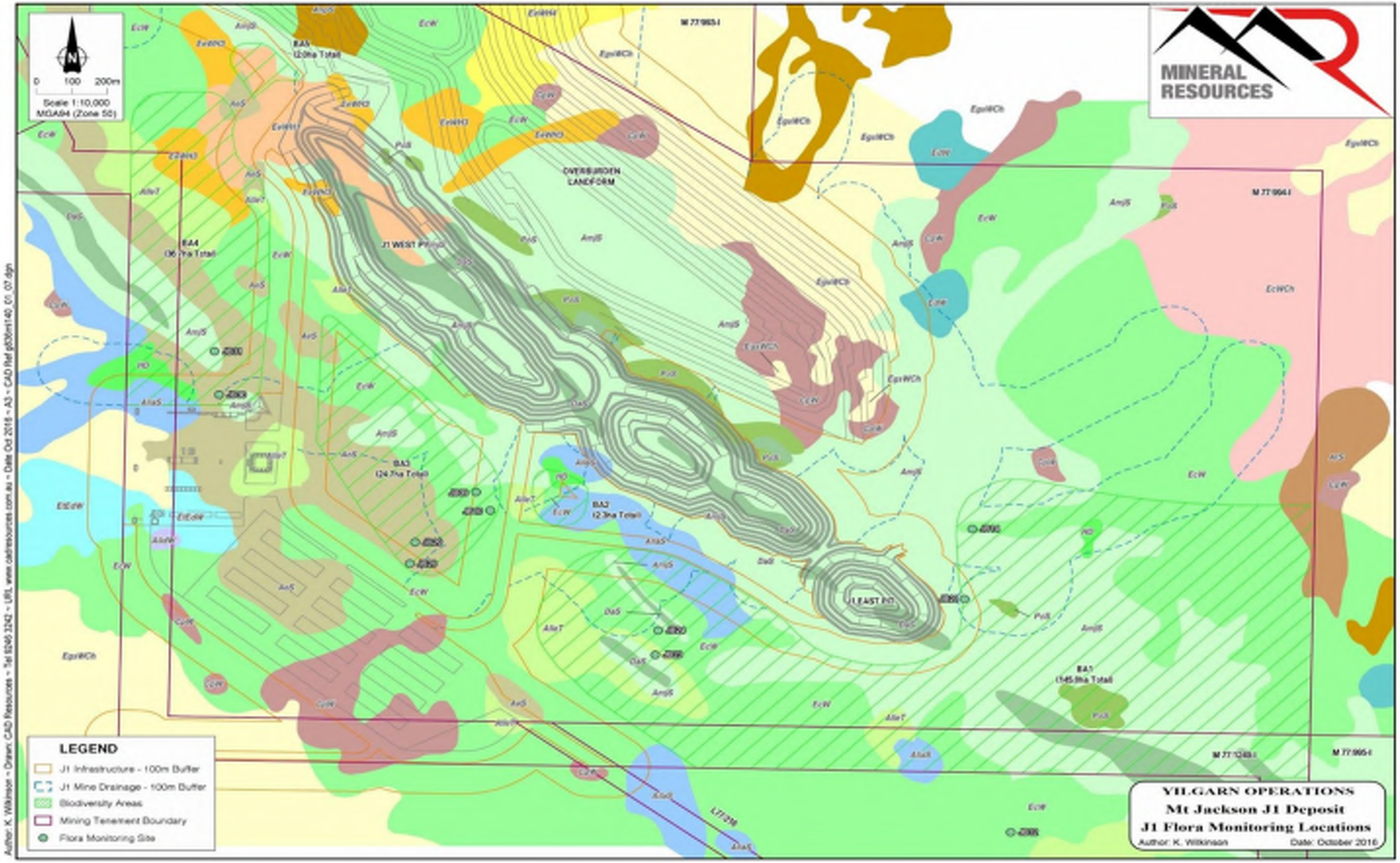

Figure 2.1**: Location of monitoring plots in relation to mining activities and vegetation unit distributions.**

3 Rainfall

Monitoring of flora condition at the Windarling operations between 2003 and 2009 has identified rainfall as the main limiting factor, affecting plant condition and survival (Western Botanical 2010). Rainfall recorded at the Windarling Range weather station (approximately 36km away) was reviewed to assist with data interpretation. Rainfall data is presented in Figure 3.1 and Figure 3.2 below.

Error! Reference source not found. shows the total rainfall recorded prior to each monitoring event. A total of 259.3mm of rainfall fell at Windarling in the 12 months prior to the 2018 monitoring and this was slightly less than the long term average annual rainfall of 272.3mm (BoM 2018). Although the rainfall data from the Windarling weather stations is not exactly the same as the rainfall received at Mt Jackson, it is assumed to be similar.

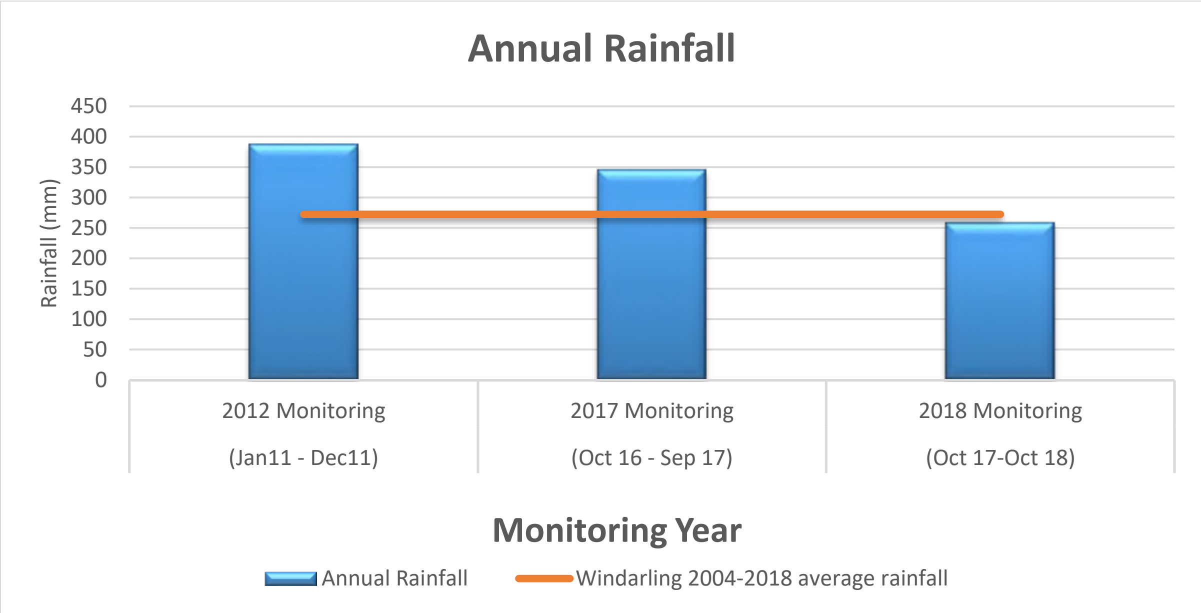

Figure 3.1: Total rainfall recorded prior to each monitoring event vs. Windarling annual average.

Figure 3.2 shows the monthly rainfall recorded at Windarling in the 12 months prior to the monitoring season, overlaid with the 2004 to 2018 monthly average. Prior to the 2018 monitoring, five months, (December, January, February, June and August) recorded a rainfall higher than the 2004-2018 monthly average. Almost half (48%) of the total rainfall received prior to the 2018 monitoring fell during the summer months (Dec- Feb) with the two months leading up to the monitoring event (September and October 2018) only recording 2mm in total.

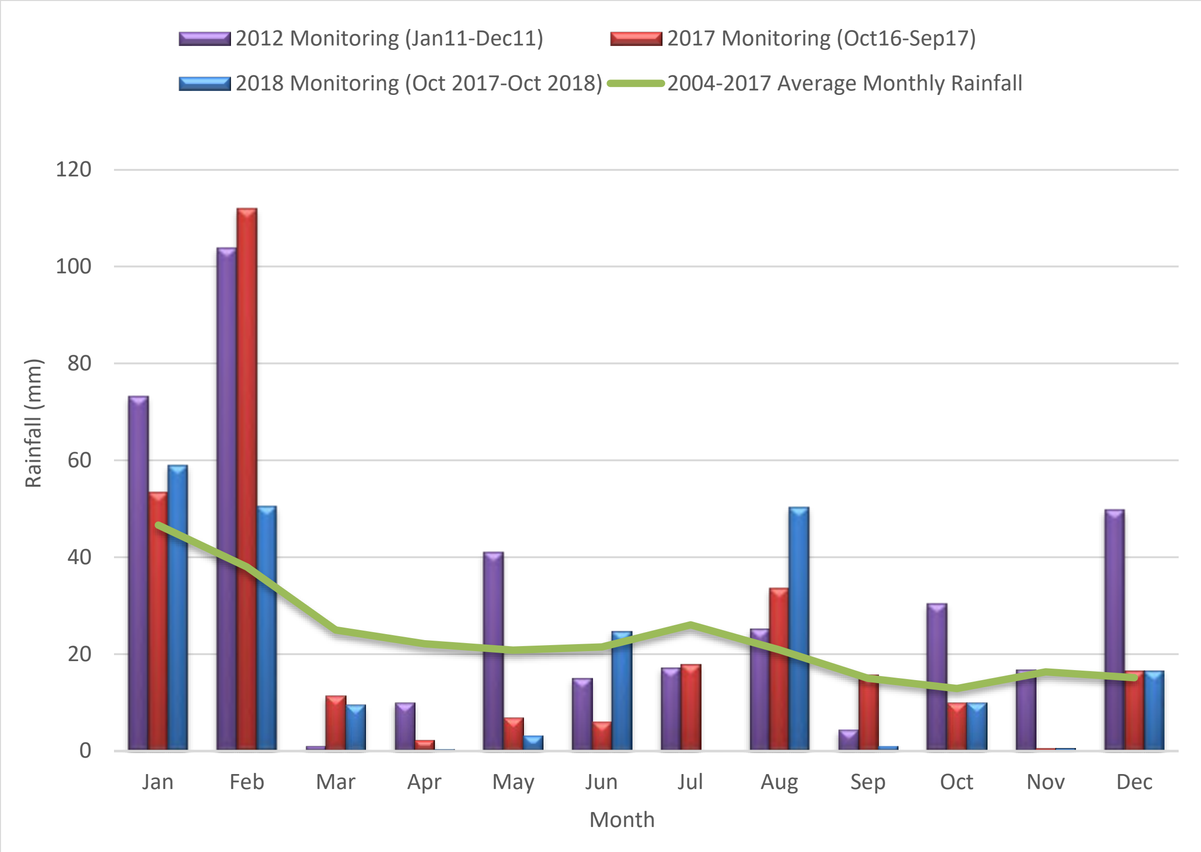

Figure 3.2: Total monthly rainfall recorded at Windarling prior to monitoring, as well as the 2004-2018 average monthly rainfall.

4 Results

A photographic record of each plot is presented in Appendix 1.

4.1 Vegetation condition

Figure 4.1 presents the results of vegetation condition monitoring of plots monitored in 2012, 2016, 2017 and 2018. The 2018 monitoring found all plots were ranked in the 'Excellent' category, similar to the 2017 monitoring when all but one plot were ranked 'Excellent'. The vegetation in all plots was found to be in the same or healthier condition than recorded in 2012.

Figure 4.1: Vegetation condition of plots monitored in 2012, 2016, 2017 and 2018.

4.2 Flora Condition

The results of the 2018 flora condition monitoring are presented in Figure 4.2, along with the results of the 2016 and 2017 monitoring. The 2018 monitoring found plants within the AmjS vegetation unit were in a significantly healthier condition in the plot near mining as compared to the control plots, with those near mining recording 100% in the 'Healthy' condition category compared with 66% in the control plots. Individuals within the EcW control plots increased slightly in health from 2017 to 2018, whilst those in the EcW near mining plots saw some decline in the 'Healthy' condition category but showed significant recovery in the 'Stressed' condition category (Figure 4.2). Individuals within the AeS vegetation unit near mining recorded a decline within the 'Healthy' category between 2017 and 2018; whilst those in the control plots returned to 2016 levels.

Individual plant monitoring identified a slight decrease in the overall number of "Healthy" individuals between 2018 and 2017. A decline of 4.8%, from 77.5% in 2017 to 72.7% in 2018 over all plots. Further analysis of the data identified that there were greater declines in the control locations when compared to plots close to mining. Control plots showed a 5.8% decline between 2017 and 2018, while near mining plots only identified a 3.8% decline.

Overall the 2018 monitoring found plants in all vegetation units were in a healthy condition. There was minimal differentiation in the health of individuals near mining compared to control locations, with the exception of the AeS vegetation group which showed a slight increase in the number of plants in the slightly stressed category in the near mining plots and an improvement in the health of the plants in the control plot when compared to the 2017 results. Overall, the majority of plants near mining were in a similar or healthier condition to those in the control locations.

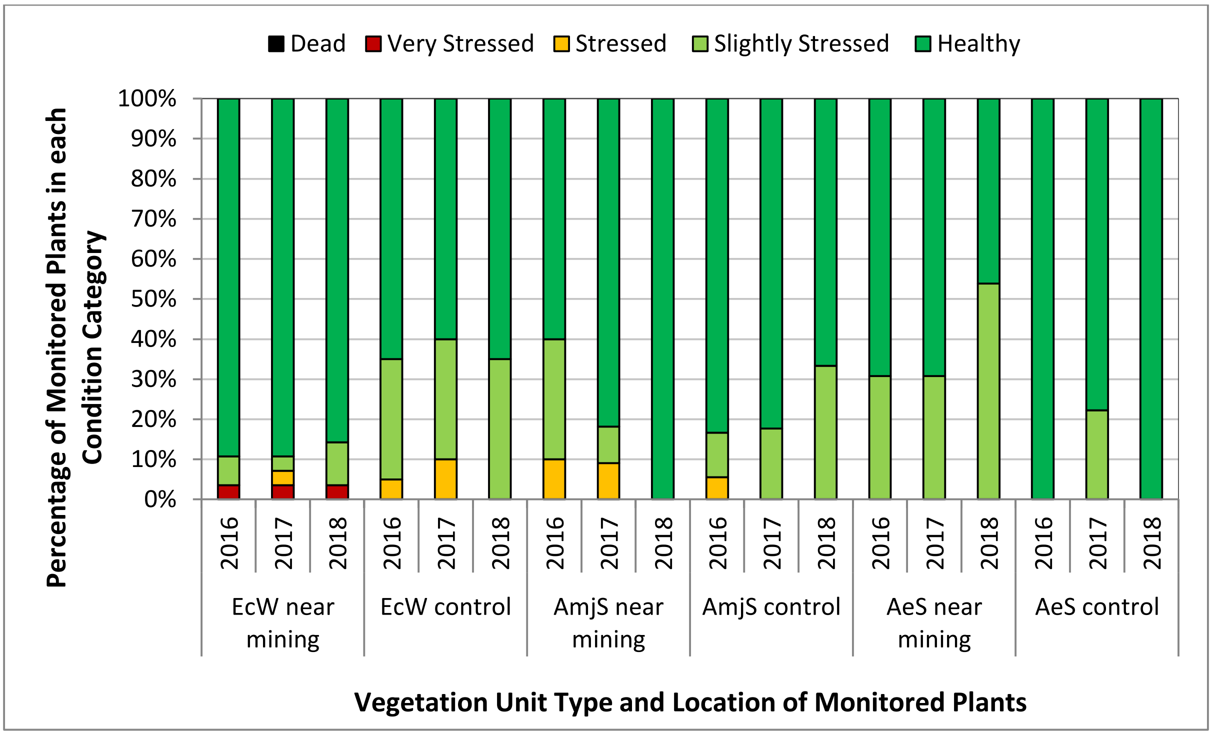

Figure 4.2: Health condition of monitored plants from 2016 – 2018.

4.3 Leaf Dust

Figure 4.3 presents the results of dust loading on monitored plants from 2016 through to 2018. All plots showed a marked improvement on leaf dust loads, with no dust recorded on any of the individuals. This was in large part due to a rainfall event preceding the monitoring coupled with reduced mining activities within the Mt Jackson J1 area.

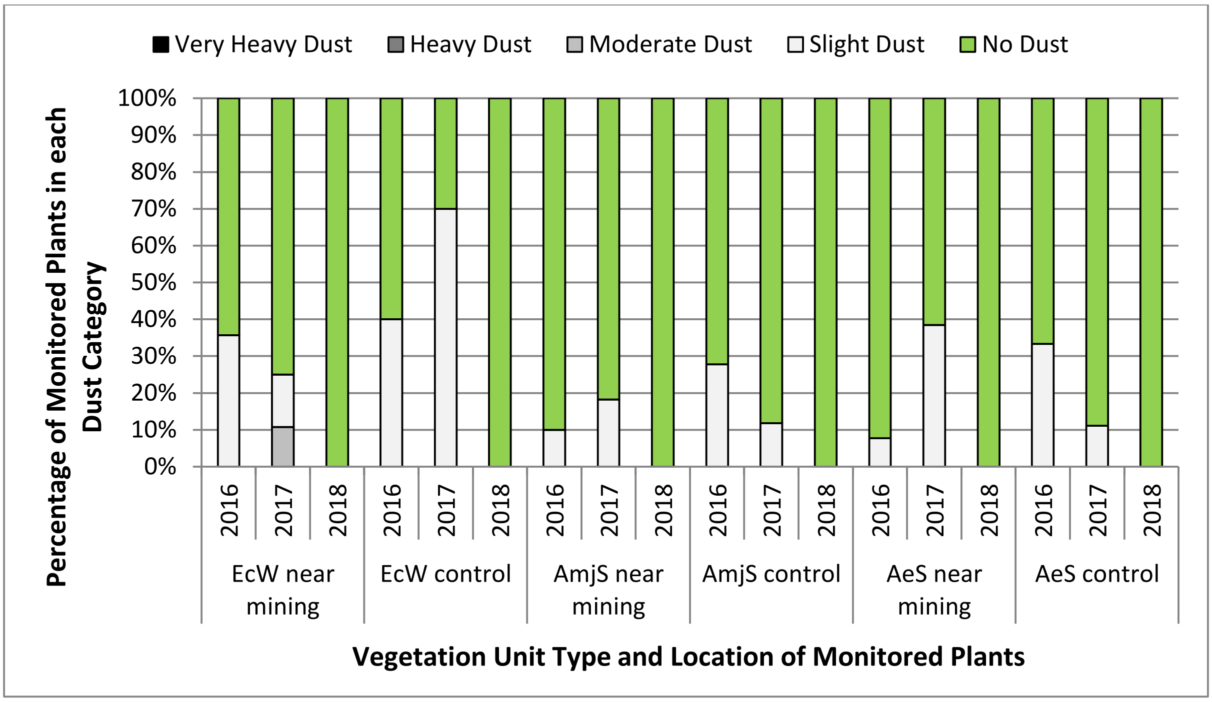

Figure 4.3: Leaf Dust condition of monitored plants from 2016 – 2018

4.4 Chlorophyll Fluorescence Monitoring

Figure 4.4 presents the results of the chlorophyll fluorescence (CF) monitoring conducted in 2018 compared to levels measured in 2017. Average chlorophyll fluorescence (Fv/Fm) ranged between 0.73 (AmjS control) and 0.79 (AeS near mining and control). There was minimal differentiation in average chlorophyll fluorescence based on distance from mining. When compared to 2017, all plots recorded higher CF readings in 2018 indicating individuals were less stressed.

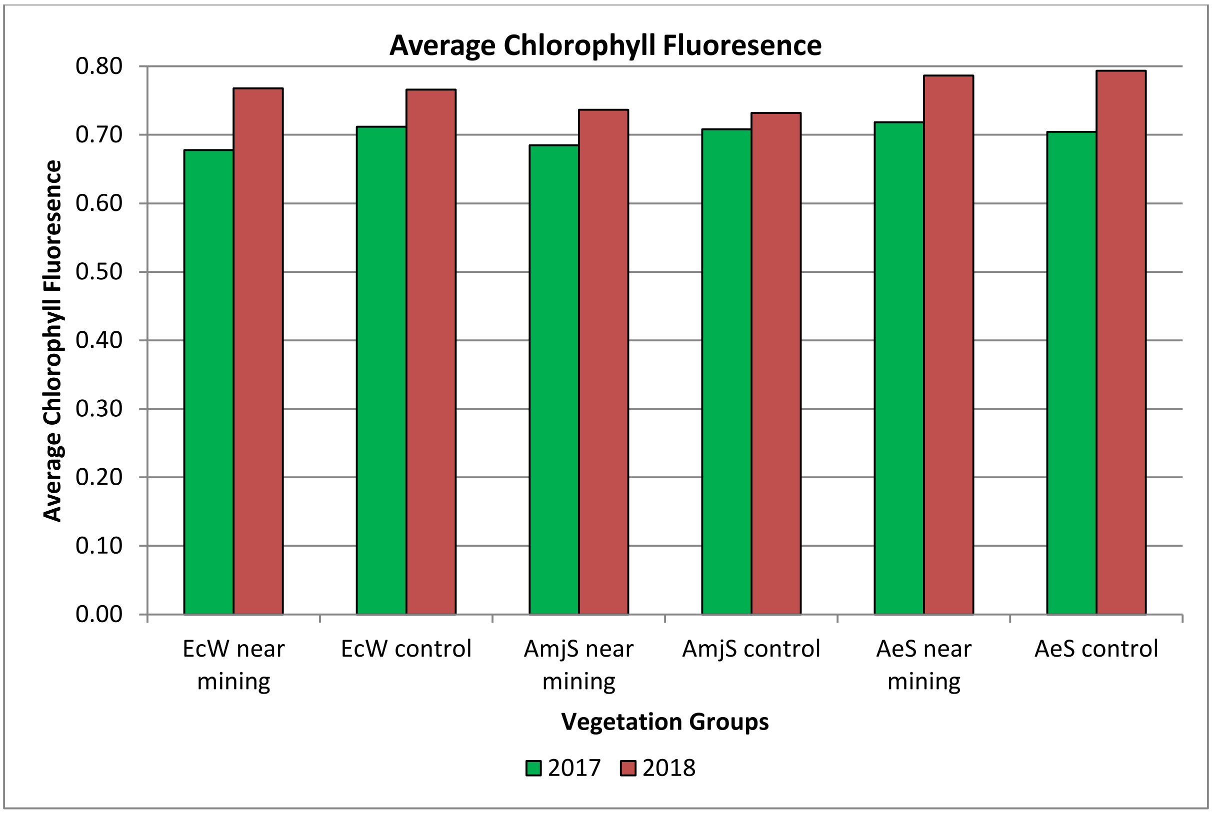

Figure 4.4: Chlorophyll fluorescence of monitored plants during 2018 and 2017.

4.4.1 Priority Flora

Figure 4.5 presents the results of the CF monitoring on *Stenanthemum newbeyi* individuals. The average CF value of *Stenanthemum newbeyi* near mining was 0.69 as compared to 0.75 in the control plots. Both locations saw a slight improvement when compared to the 2017 results. Overall, all of the *Stenanthemum newbeyi* individuals were considered healthy during the 2018 monitoring as levels were well above 0.6 which indicates individuals are unlikely to be stressed.

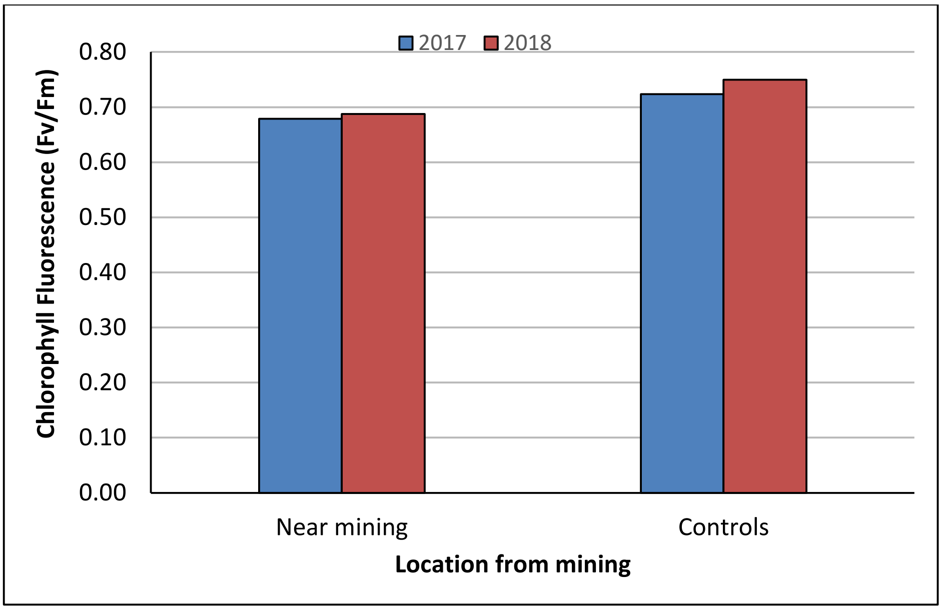

Figure 4.5: Chlorophyll Fluorescence monitoring of Priority Flora during 2018 and 2017.

4.5 Weeds

No weeds were observed or recorded in the monitored plots during the 2018 monitoring event.

5 Discussion

The condition of vegetation in all plots was observed to be in 'Excellent' or 'Very Good' condition as defined by Keighery (1994). These results suggest that mining activities are not currently having a negative effect on the condition of the vegetation surrounding the Mt Jackson J1 operations.

The 2018 individual plant monitoring data showed a slight overall decline in health when compared to 2017. The majority individuals adjacent to mining were in a similar or healthier condition to those in the control locations with the exception of the AeS vegetation group where the control plot recorded a higher percentage of individuals in the 'Healthy' condition category. It should be noted that this form of monitoring is somewhat subjective and provides more of a qualitative assessment of the vegetation.

Dust levels were not identified as a limiting factor during the 2018 monitoring as all individuals were recorded as dust free. This was due to reduced mining activities within the J1 area and a rainfall event that preceded the 2018 monitoring.

Average chlorophyll fluorescence value is a more reliable indicator of plant health than condition assessment. This method directly measures physiological function and thus offers significant advantages over the more traditional measures of vegetation condition that use indirect indicators such as dead/live leaf material or leaf colour. Fv/Fm (index of chlorophyll fluorescence) has a normal range of 0.7 to 0.8 across a broad range of different vascular plan taxa. The ratio declines when plants are under conditions of stress. Various literatures (Ritchie 2006; Percival 2005) suggest values below 0.6 indicate plant stress. The 2018 monitoring found average chlorophyll fluorescence was similar across all monitoring locations, ranging between 0.73 and 0.79 compared to 2017 where values ranged between 0.68 and 0.72. This indicates that overall vegetation monitored is experiencing less stress and is in a healthier condition when compared to the 2017 monitoring results.

The 2018 monitoring of Priority Flora individuals found those near mining had a slightly lower average chlorophyll fluorescence value (0.69) than individuals in the control locations (0.75), however were still considered healthy. Again the results from 2018 show an improvement when compared to the 2017 monitoring results (Figure 4.5).

These individuals will continue to be monitored for changes in health and future monitoring will provide more information on whether mining is affecting these individuals.

No weeds were recorded in the monitoring plots.

Future monitoring will provide further insight into the effects (if any) adjacent mining activities are having on the vegetation and flora of Biodiversity Areas.

5.1 Comparisons against trigger and threshold criteria

The Flora and Vegetation Management Plan (Cliffs 2016) outlines trigger criteria that require further reporting and contingency actions. The following section compares the results of the monitoring against the relevant criterion.

1) Annual monitoring indicates a decline of greater than 15% in the plant condition at monitoring sites relative to reference sites and rainfall is >150mm between annual sampling dates.

   The monitoring found plant condition remained similar to the 2017 monitoring, with individuals near mining in a similar or healthier condition to those in the control locations. There was no decline greater than 15% detected during the 2018 monitoring, as shown in Figure 4.2 and described in Section 4.2.

2) Any direct effect on conservation significant flora occurs as a result of mining activities.

   Data indicates that conservation significant flora occurring within the monitoring area has not been affected by mining activities.

3) Any significant short them (i.e. <1 year) decline in conservation significant flora is detected at any time.

   Conservation significant flora has shown an improvement in health over the past year.

4) Annual monitoring indicates a spatial pattern of decreasing plant condition and/or higher mortality that may be related to proximity to mining operations.

   The 2018 individual plant monitoring data showed a slight overall decline in health when compared to 2017. The majority individuals adjacent to mining were in a similar or healthier condition to those in the control locations with the exception of the AeS vegetation group where the control plot recorded a higher percentage of individuals in the 'Healthy' condition category.

   The 2018 monitoring of Priority Flora individuals found those near mining had a slightly lower average chlorophyll fluorescence value (0.69) than individuals in the control locations (0.75), however were still considered healthy. Again the results from 2018 show an improvement when compared to the 2017 monitoring results.

These results suggest that mining activities are not currently having a significant effect on the condition of the vegetation surrounding the Mt Jackson J1 operations.

6 References

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7 Appendix 1

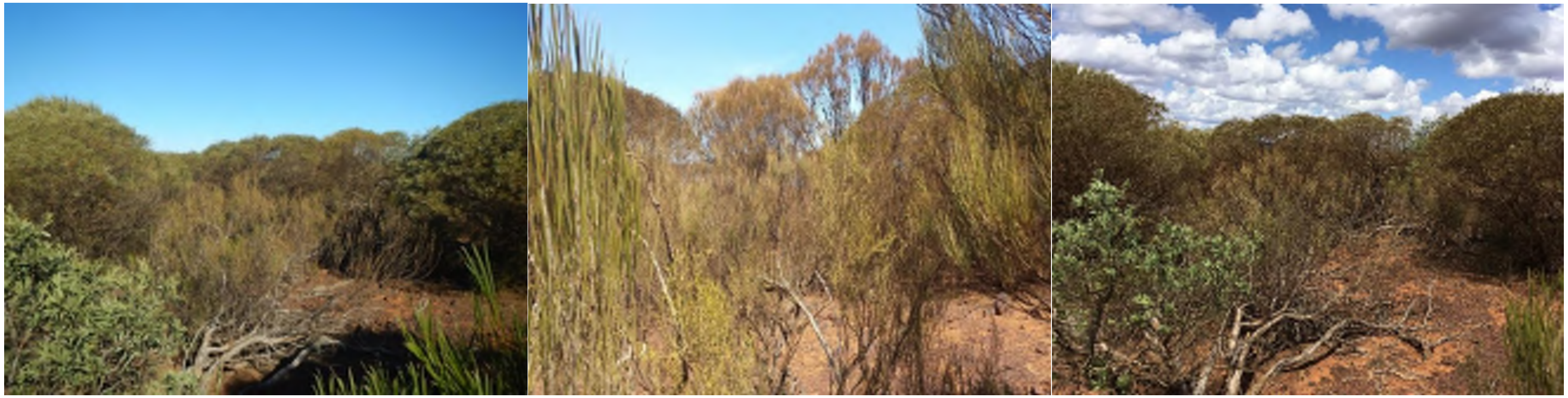
Photographic Record of Vegetation and Flora Condition

Photo 1, 2 and 3: JB09 2016 (left), 2017 (centre) and 2018 (right)

Photo 4,5 and 6: JB10, 2016 (left), 2017 (centre) and 2018 (right)

Photo 7,8 and 9: JB14, 2016 (left), 2017 (centre) and 2018 (right)

Photos 10, 11 and 12: JB21, 2016 (left), 2017 (centre) and 2018 (right)



Photos 13, 14 and 15: JB23, 2016 (left), 2017 (centre) and 2018 (right)

Photos 16, 17 and 18: JB24, 2016 (left), 2017 (centre) and 2018 (right)

Photos 19, 20, and 21: JB28, 2016 (left), 2017 (centre) and 2018 (right)

Photos 22, 23 and 24: JB29, 2016 (left), 2017 (centre) and 2018 (right)

Photos 25, 26 and 27: JB30, 2016 (left), 2017 (centre) and 2018 (right)

Photos 28, 29 and 30: JB31, 2016 (left), 2017 (centre) and 2018 (right)

Photos 31, 32 and 33: JB32, 2016 (left), 2017 (centre) and 2018 (right)

Attachment 12 – Lake K Vegetation Monitoring Report 2018

2018 Assessment of Fringing Vegetation at Lake K

Prepared for:

Mineral Resources Limited

November 2018

Prepared by:

Martinick Bosch Sell Pty Ltd
4 Cook Street
West Perth WA 6005
Ph: (08) 9226 3166
Fax: (08) 9226 3177
Email: info@mbsenvironmental.com.au
Web: www.mbsenvironmental.com.au

2018 Assessment of Fringing Vegetation at Lake K
November 2018

Distribution List:

Company	Contact name	Copies	Date
Mineral Resources Limited	Neil Smith Environmental Superintendent	[01]	26 November 2018
Mineral Resources Limited	David Swain Team Leader Environment and Heritage	[01]	26 November 2018

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Draft Report for client review	Thomas Robson	Kristy Sell	22 November 2018
Final Report	Thomas Robson	Kristy Sell	26 November 2018
Final Report (Revision 1)	Thomas Robson	Alan Wright	5 December 2018

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APPENDICES

1. BACKGROUND

The previous operators of the Mineral Resources Limited (MRL) iron ore operations at Koolyanobbing, Cliffs Asia Pacific Iron Ore Pty Ltd (Cliffs), conducted dewatering operations at the Koolyanobbing mine from 1999. Dewatering commenced under Works Approval No. 2720 (11 May 1999) and has been carried out in accordance with Groundwater Licence GWL154459 and Environmental Licence 5850 since that time.

The hypersaline water drawn from pits is discharged into a semi-enclosed section of Lake Deborah East, known as ‘Lake K’, located approximately 3 km north west of the Koolyanobbing mine site. Lake K is physically separated from its natural downstream overflow discharge into Lake Deborah East Major by a causeway and road servicing the W.A. Salt Supply operations to the north (Figure 1).

To comply with Commitment 6 of Notice of Intent (NOI), Koolyanobbing Dewatering of Pit K, and the current Environmental Licence 5850 (DER 2013), Cliffs initiated a vegetation monitoring program around the edges of the lake to identify the condition of, and any adverse impacts upon, the fringing vegetation. Vegetation monitoring commenced in December 1999, after a series of transects and quadrats were established in fringing vegetation upstream, adjacent to, and downstream of, the discharge point in Lake K (URS 2004). Monitoring was conducted annually by URS Australia Pty Ltd (URS) between 1999 and 2004. Western Botanical reviewed the program in 2005 and implemented a new methodology in October 2006; incorporating a series of Tape Intercept Transects to monitor the halophytic fringing vegetation of the Lake Deborah System (Western Botanical 2006). In addition, a series of mesophytic large shrub and small tree species were tagged and an estimate of their condition was recorded. The 2018 monitoring event represents the 13th year using this revised methodology, which was conducted internally by Cliffs since 2011 and by MBS Environmental (MBS) on behalf of MRL in 2018.

The surface water present at Lake K is largely attributed to the causeway stopping the natural flow downstream, along with water added by dewatering discharge. During high rainfall events, the surface water collected at the causeway is more likely to intrude on the fringing vegetation than at surrounding sites.

During the 2006 monitoring program (Western Botanical 2006) it was reported that the condition of vegetation on the margins of Lake K were poorer than that of nearby, but hydrologically isolated, parts of the Lake Deborah system with similar topography and soil types. These observations are still applicable, although to a lesser extent, and are attributed to an extreme rainfall event in 1999 filling the lake and flooding the fringing vegetation with saline surface water. The annual trends at Lake K since this event have been comparable with the other lakes within the system over the past number of monitoring periods.

There have been good signs of recovery recorded in the past at Lake K, including Samphire (*Tecticornia* spp.) recruitment throughout the fore dune. The declining trend in halophytic vegetation condition first observed during the 2007 monitoring stabilised across most sites in 2012, and only relatively minor changes were recorded between 2013 and 2017. Additionally, the large mesophytic shrubs and small trees that are found immediately upslope of the halophytic vegetation zones showed only minor change in condition at all sites over the 2015 to 2017 period.

This report presents and discusses the results of the 2018 monitoring of vegetation at Lake K and two reference sites, Southern Lake and Lake Deborah East Major.

2. METHODS

MBS Environmental conducted the 2018 monitoring between 10 and 15 September 2018, following the methods outlined in the most recent annual monitoring report (Cliffs 2018). Nine monitoring sites exist on the south eastern banks of the Lake Deborah System, as shown in Figure 1 and listed in Table 1.

Table 1: Location of Monitoring Sites and Transects

Lake Section	Transects
Lake Deborah East Major	KL7, KL8, KL9
Lake K (receiving saline discharge)	KL1, KL2, KL3
Southern Lake	KL10, KL11, KL12

Figure 1: Location of Monitoring Plots Within the Lake Deborah System

2.1 TAPE INTERCEPT TRANSECT MONITORING

At each monitoring site, a series of five tape intercept transects were established at ten metre intervals, perpendicular to the lake edge. Transect length varied depending on the length required to capture sufficient fringing vegetation material, ranging between 14 m and 20 m. At each monitoring site, the start of the first transect is marked with a galvanized steel star picket, at a point set back from the beach within the lake bed. The remaining transects are marked at their respective start and finish points with short wooden stakes, as illustrated in Figure 2.

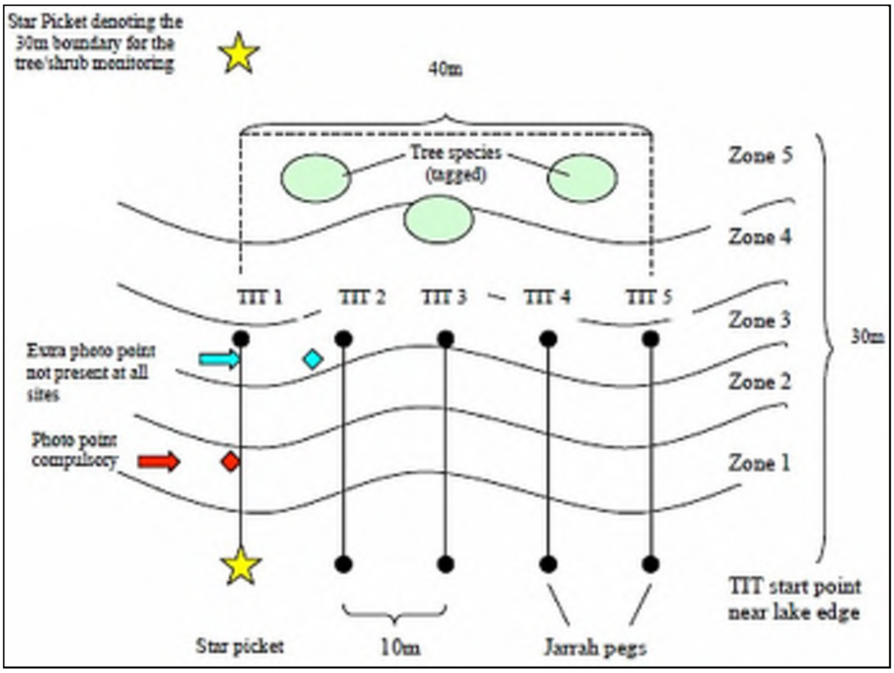

Figure 2: Typical Layout of Monitoring Plots at Nine Monitoring Locations

The tape intersect transect monitoring involved measuring the distance, from the start of the transect to the exact point where there is a change in the vegetation that intercepts the line. To do this, a tape measure is run out between the two pegs that mark the limits of each transect (see filled black circles in Figure 2), starting from zero cm at the lake bed. Where a change in vegetation is noted, a measurement is taken from the tape, giving exact distances for ground cover type within the transect, and allowing the same features to be remeasured each year. This is important for monitoring annual changes in the area of live and dead plant material and bare ground cover. Due to observed senescence within plant canopies, the 2007 monitoring program refined the measures recorded during the initial 2006 program, increasing the level of separation where patches of bare ground or dead plant occur within a live plant to provide a more accurate representation of change in ground cover. These refined methods have been followed since 2007, allowing the 2007 program to act as a baseline for long-term analysis. An exception to this was found during the 2009 monitoring, where the sites at Lake Deborah East Major, particularly transects KL7 and KL8, were found not to have been brought into consistency with the rest of the monitoring program. As such, during the 2009 monitoring there was a large increase in dead material and an inverse decrease in live plant material recorded at these sites. Following this modification, the 2009 program has been used as a baseline for analysis of Lake Deborah East Major.

2.2 TREE AND SHRUB MONITORING

The condition of the large mesophytic shrubs and small tree species adjacent to the lake margins were also monitored. Each large shrub or small tree within a 40 x 30 m area upslope of the transects, along with any growing nearer to the lake edge within the transect zone, were tagged with an individually numbered plastic tag, excluding individuals under 0.5 m in height. The 40 x 30m area was delineated by the shore line within the transect zone and a star picket higher in the dune, previously installed by URS to mark the end of the transect employed in their previous methodology (Figure 2, URS 2004).

Table 2 lists all taxa encountered in the large mesophytic shrub and small tree monitoring. The monitoring involved recording the species, its unique tag number, approximate dimensions and an estimate of the plant's condition (percentage of live canopy versus total plant volume).

Table 2: Mesophytic Shrub and Tree Species Monitored

Species
Acacia inceana subsp. conformis
Acacia sp. Mt Jackson
Acacia acuminata
Acacia tetragonophylla
Callitris columellaris
Dodonaea viscosa subsp. angustissima
Eremophila decipiens
Eremophila miniata
Eremophila oppositifolia subsp. angustifolia
Exocarpos aphyllus
Jacksonia arida
Pimelea microcephala
Pittosporum angustifolium
Santalum spicatum
Scaevola spinescens
Senna charlesiana
Templetonia smithiana

2.3 PHOTO MONITORING

Photographic monitoring points were established at each site in 2006 to provide a visual record for evaluating the health of fringing vegetation over time. Two wooden stakes were installed to mark the point where (a) the photo was taken and (b) the centre point of the field of view to ensure the same image is captured during each round of monitoring. The photographic results are shown in Appendix 1. These photographic monitoring points approximate those employed by URS in previous monitoring at these sites (URS 2004).

3. RAINFALL

Koolyanobbing is a Bureau of Meteorology (BoM) registered rainfall observation site, where rainfall data has been collected since 2001. The total rainfall recorded prior to each monitoring season from 2007 to 2018 is presented in Figure 3, as well as the 2006 - 2018 average annual rainfall. Koolyanobbing received 284 mm rainfall prior to the 2018 monitoring event (July 2017 - June 2018), with over half (52%) falling during January and February 2018. The total annual rainfall received prior to the 2018 monitoring was less than the 343 mm recorded prior to the 2017 monitoring, and closer to the long-term average of 271 mm (BoM 2018).

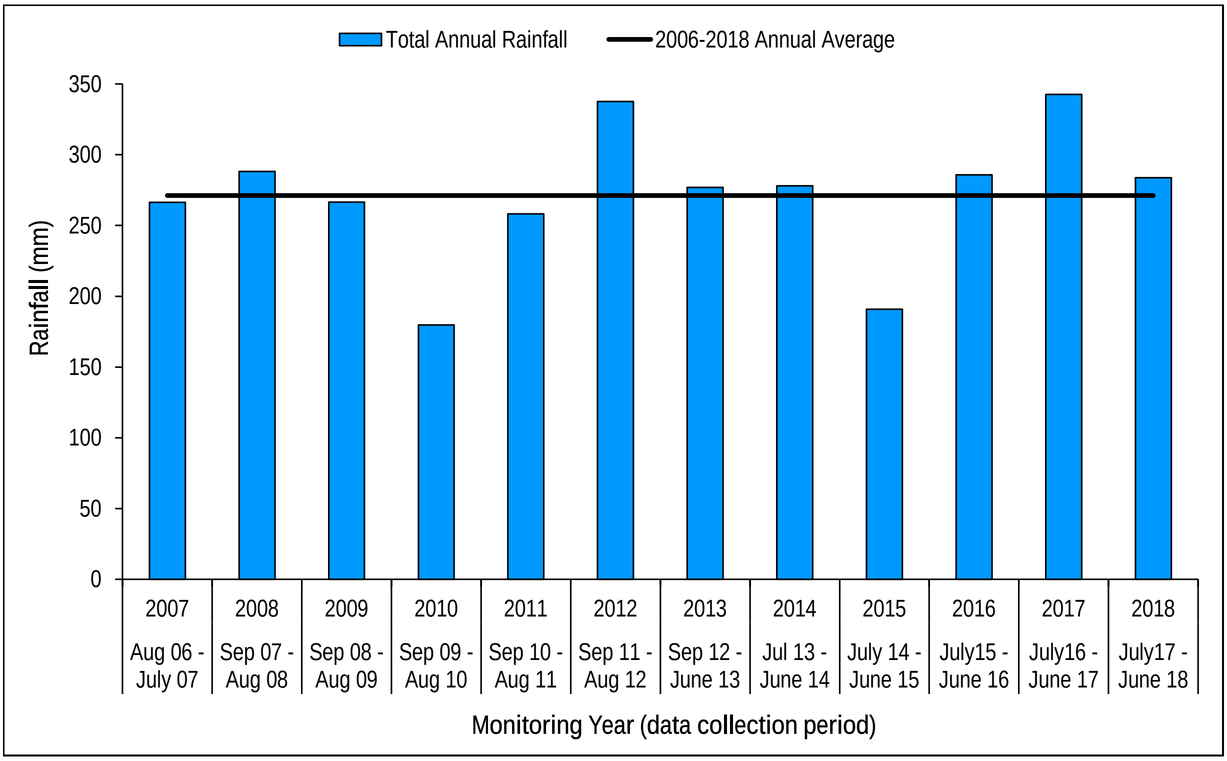

Figure 3: Annual Rainfall Received Prior to Annual Monitoring (2007-2018)

4. RESULTS

4.1 GENERAL OBSERVATIONS

4.1.1 Lake K

During the initial monitoring in 2006, there was a noted fringe of samphire (*Tecticornia* spp.) deaths and declining condition at all transect locations along Lake K. This was attributed to surface water intrusion resulting from an extremely high rainfall event. Plant deaths were most frequent within the first three metres from the lake edge and more noticeable nearby the causeway. During the 2007 monitoring, the deaths appeared to have extended further, to within the first 10 m of the shoreline. This trend continued but did not significantly worsen, as shown by monitoring between 2008 and 2010, with many samphires near the shoreline dying back. The 2011 monitoring found this declining trend had stabilised, and new growth was also recorded on some of the samphires during 2012. Monitoring between 2013 and 2017 found the stabilised trend continued for the most part, with minor new growth and minor dieback of samphires observed, a trend corroborated by the findings of the 2018 monitoring event (Appendix 1). Percentage cover of bare ground, live plants and dead plants varied by <1% along Lake K, relative to values recorded during the 2017 monitoring.

4.1.2 Lake Deborah East

During 2010, the near shore vegetation at all sites within Lake Deborah East Major was observed as being in generally poorer condition than in previous years, highlighting the stress from a period of significantly lower than average rainfall prior to monitoring. The 2011 and 2012 monitoring found this vegetation to be in slightly healthier condition than in 2010, with new healthy growth observed on some individuals. Monitoring between 2013 and 2017 found a minor decrease in live plant cover, particularly evident at transect KL7. In contrast, the 2018 monitoring indicated minor improvement in the fringing community, relative to data from the 2017 monitoring event, marked by decreased bare ground cover (4.1%) and dead plant cover (1.1%), matched by increased live plant cover (5.2%). As previously discussed (Cliffs 2018), there is no evidence that a link exists between the decline in live plant cover observed between 2013 and 2017 and the dewatering operations near the causeway, as the surface water present at Lake K is isolated from Lake Deborah East Major. It is likely that the improvement observed in 2018 reflects annual variation in rainfall, following three successive years with average or greater than average annual rainfall in the region (Figure 3).

4.1.3 Southern Lake

Between 2008 and 2011 there was an observed decline in samphire condition at the Southern Lake; this decline being particularly evident at the lake edge, isolated to the shoreline and most apparent at transect KL10 (Appendix 1). The fringing community at Southern Lake has been relatively stable since 2012, and the 2017 monitoring results indicated a large increase in live plant cover at KL10 relative to 2016. Although the 2018 monitoring found live plant cover at KL10 decreased (6.3%) and bare ground cover increased (10.9%) relative to 2017, results from the other transects along the lake shoreline (KL11 and KL12) indicated improvement since 2017. Across all transects, average live plant cover at Southern Lake increased by 3.3% and, as previously discussed, this may be associated with three successive years of at least average annual rainfall in the region (Figure 3).

4.2 TAPE INTERCEPT TRANSECT MONITORING

Compared with results from the 2016 - 2017 monitoring period, the proportion of bare ground recorded at all but one transect (KL10) either remained stable (i.e. within 1% of 2017 results) or decreased (Figure 4). Bare ground cover at KL10 (Southern Lake) increased by 10.9% relative to 2017, whereas proportional decreases of between 2.9% and 8.8% were observed at Southern Lake (KL11 and KL12) and Deborah East Major (KL8 and KL9). Compared with 2017, bare ground cover at Lake K (KL1, KL2 and KL3) remained stable. With the exception of transect KL9 (Lake Deborah East), the percentage of bare ground cover recorded at each site in 2018 was greater than when monitoring began (2007/2009), with decreases ranging between 4.5% (Southern Lake: KL11) and 14.1% (Lake K: KL2). Relative to the 2007/2009 monitoring, percentage bare ground at site KL9 has decreased by 1.9%.

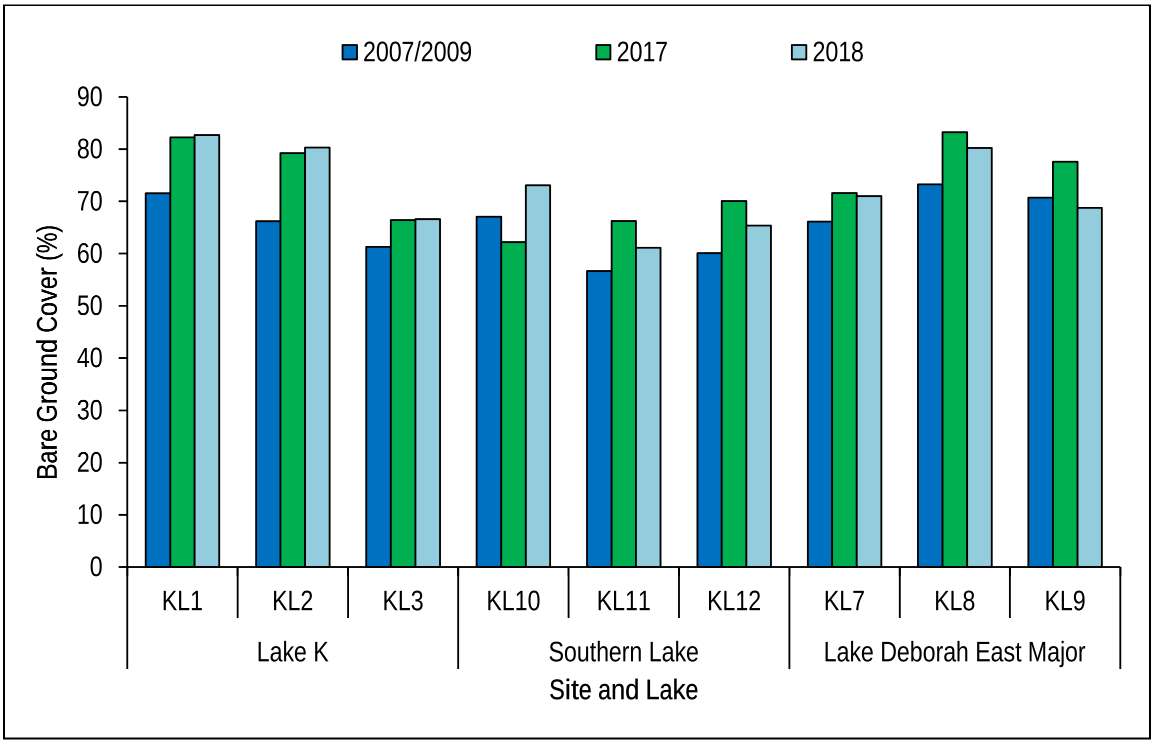

Figure 4: Percentage Bare Ground Cover at Each Site (2007/2009 – 2018)

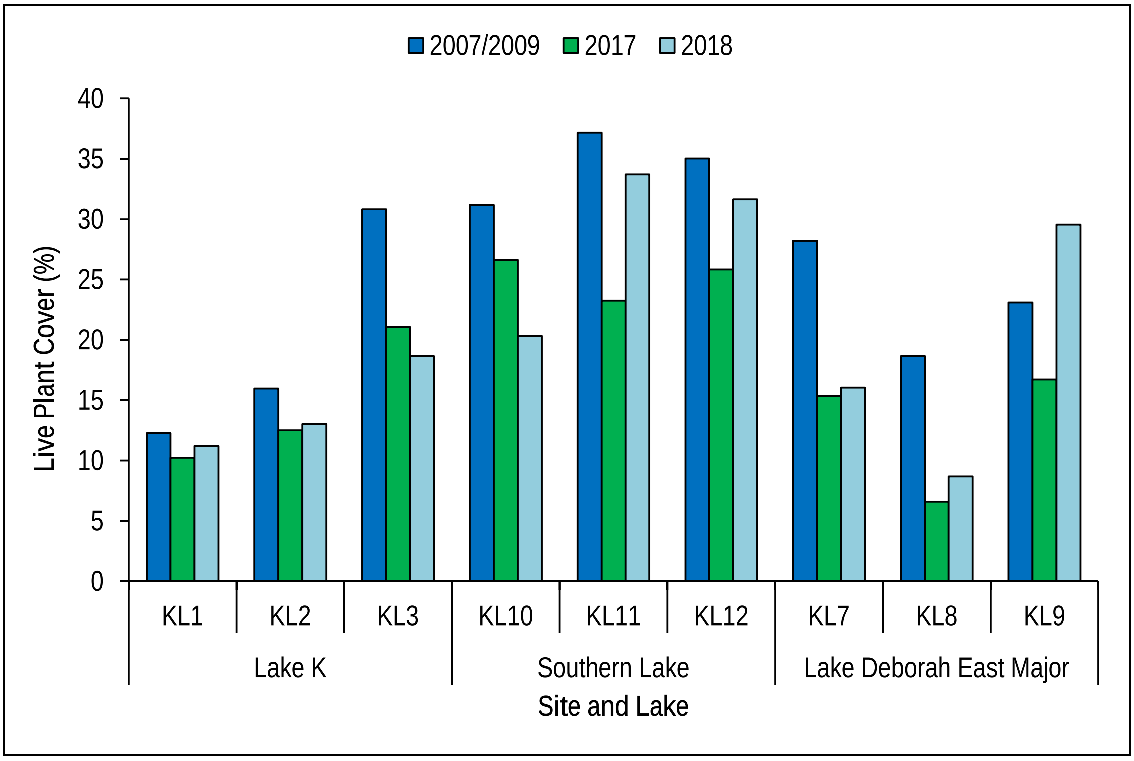

Figure 5: Percentage Live Plant Ground Cover (2007/2009 – 2018)

Comparing the proportion of live plant cover observed in 2018 with results from the 2016 – 2017 monitoring period indicated that the percentage live plant cover increased at most sites (Figure 5). Percentage live plant cover increased or remained stable (± 1%) at sites on Lake K (KL1 and KL2), Southern Lake (KL11, KL12) and Lake Deborah East (KL7, KL8 and KL9). The increases ranged between 2.1% and 12.8% (Lake Deborah East: KL8 and KL8), whilst decreases of 2.4% and 6.3% were also recorded at Lake K (KL3) and Southern Lake (KL10), respectively. The percentage live plant cover recorded in 2018 was reduced at all sites compared with results from when monitoring began (2007/2009) with the exception of transect KL9 (Lake Deborah East Major), where live plant cover increased by 6.4%. Live plant cover decreased at the other locations by between 1.1% and 12.2%, whereby the most substantial decreases (>10%) were observed for one transect at each of the three lake sections being monitored (Lake K KL3; Southern Lake KL10; Lake Deborah East KL7).

In line with results for live plant and bare ground cover from the 2018 monitoring, the proportion of dead plant coverage decreased or remained stable (± 1%) at eight out of nine monitoring locations compared with results from the 2016 – 2017 monitoring period (Figure 6). Percentage dead plant cover decreased by between 1.1% and 5.3% across all sites, with the most substantial decreases observed at Southern Lake transects KL10 (4.6%) and KL11 (5.3%) as well as Lake Deborah East KL9 (4.0%). A similar trend of decreased dead plant cover was also noted from the 2016 – 2017 monitoring results (Cliffs 2018). Compared to results from when monitoring began (2007/2009), the percentage dead plant cover has both increased and decreased within locations along each of the three sections of lake system being monitored. The most substantial decreases were at Lake K, where dead plant cover has decreased by 10.1% and 11.1% at KL1 and KL2, respectively. A substantial decrease of 7.3% was also noted for Lake Deborah East transect KL7, whereas increases of between 4.9% and 7.3% also occurred at Lake K (KL3), Southern Lake (KL10) and Lake Deborah East (KL7).

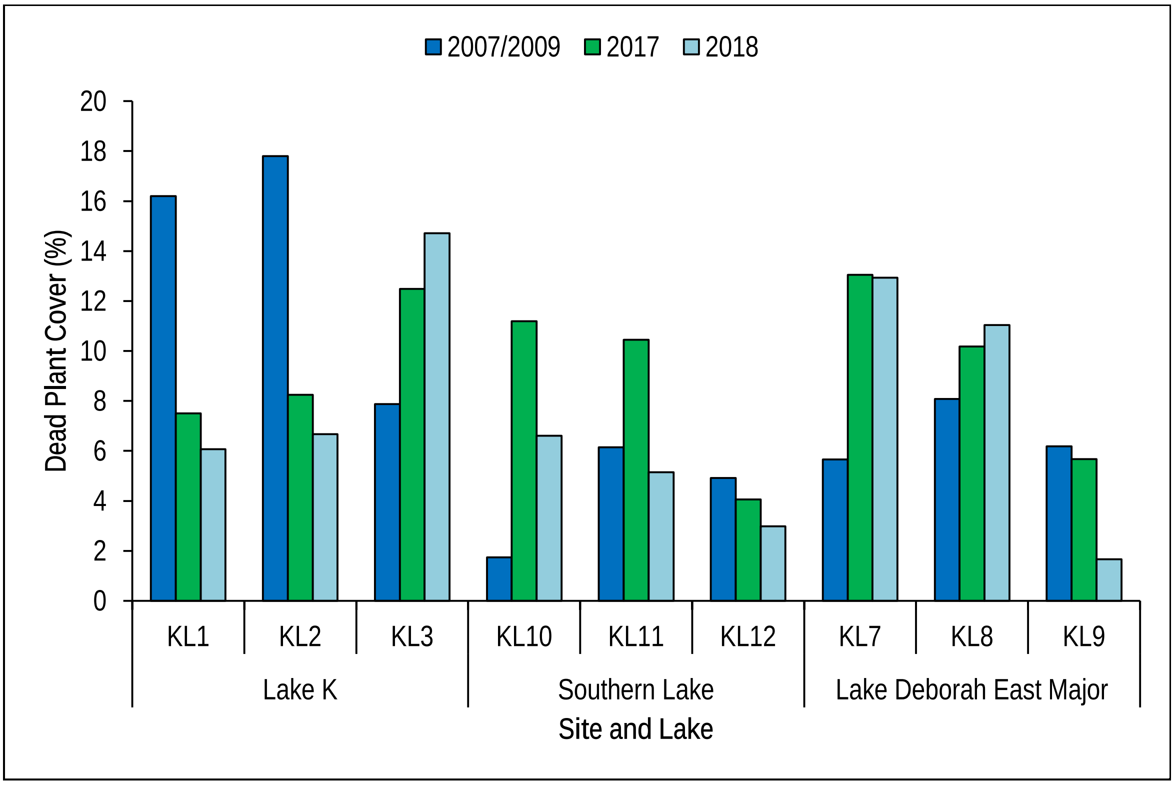

Figure 6: Percentage Dead Plant Ground Cover (2007/2009 – 2018)

Table 3 presents the change in cover type during 2018 for each site using 2007 as a baseline year for Lake K and Southern Lake, and 2009 as a baseline year for Lake Deborah East Major. The results show that the monitoring sites at Lake K are generally comparable to the two controls, if not healthier. Dead plant and bare ground cover vary across the sites and these are attributable to the whether the dead plant material has reached the stage of breaking down and being blown away (thus increasing bare ground cover) or if it is still attached to the ground (recorded as dead plant cover). With the exception of transects KL3 (Lake K) and KL9 (Lake Deborah East Major), decreases in live plant cover were recorded at all locations when compared to the baseline results. The largest decrease was recorded at transect KL8 on Lake Deborah East Major (53.6% decrease), whilst the smallest variation was recorded at transect KL1 (Lake K, 8.7%). Locations KL3 (Lake K) and KL9 (Lake Deborah East) reported relative increases of 3.7% and 27.9%, respectively, in live plant cover between 2007 and 2018.

Table 3: Percentage Cover Bare Ground, Live Plant and Dead Plant Over Time[1]

Lake	Site	Year	% Bare Ground	% Live Plant	% Dead Plant
Lake K	KL1	2007	71.5	12.3	16.2
		2018	82.7	11.2	6.1
		% Change	15.7	-8.7	-62.5
	KL2	2007	66.2	16.0	17.8
		2018	80.3	13.0	6.7
		% Change	21.3	-18.5	-62.5
	KL3	2007	72.8	18.0	9.2
		2018	66.6	18.7	14.7
		% Change	-8.5	3.7	60.0
Southern Lake	KL10	2007	67.1	31.2	1.7
		2018	73.1	20.3	6.6
		% Change	8.9	-34.9	288
	KL11	2007	56.7	37.2	6.1
		2018	61.2	33.7	5.1
		% Change	7.9	-9.4	-15.6
	KL12	2007	60.1	35.0	4.9
		2018	65.4	31.6	3.0
		% Change	8.8	-9.6	-39.2
Lake Deborah East Major	KL7	2009	66.1	28.2	5.7
		2018	71.0	16.1	12.9
		% Change	7.4	-43.1	126.9
	KL8	2009	73.3	18.7	8.1
		2018	80.3	8.7	11.0
		% Change	9.5	-53.6	36.2
	KL9	2009	70.7	23.1	6.2
		2018	68.8	29.5	1.7
		% Change	-2.7	27.9	-73.1

Figure 7 shows the annual change in cover type as a mean for each of the monitored lake sections. These results show that the three lakes are responding similarly, particularly Lake K and Lake Deborah East Major, which have similar percentage areas for each cover type (bare ground, live plant and dead plant). In comparison with the other lake sections, percentage cover of each type was relatively stable along Lake K, where bare ground, live

[1] Positive percentage difference is an increase in the measure over the period; negative percentage difference is a decrease in the measure over the period.

plant and dead plant cover varied by less than 1% compared with results from the 2016 – 2017 monitoring period. Southern Lake and Lake Deborah East experienced minor increases in live plant cover (3.3 – 5.2%) and Southern Lake also experienced a corresponding minor decrease in dead plant cover (3.7%).

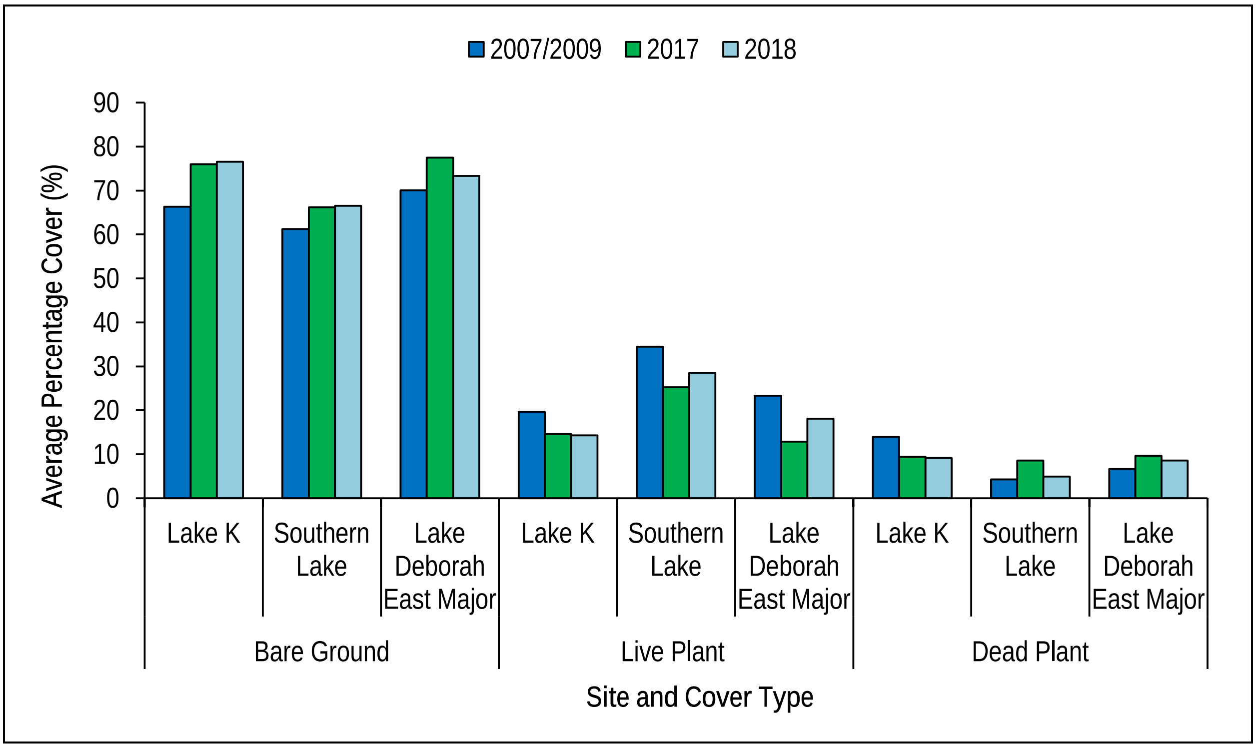

Figure 7: Mean Percentage Bare Ground, Live Plant and Dead Plant (2007 – 2018)

When compared to the baseline year (2007 for Lake K and Southern Lake; 2009 for Lake Deborah East Major), the 2018 monitoring showed that all lake sections have similarly decreased live plant cover (5.2 – 5.9%). Relative changes in dead plant cover varied by location, whereby cover decreased by 4.8% at Lake K, increased by 1.9% at Lake Deborah East, and remained at a similar level (± 1%) to the baseline assessment alongside Southern Lake. All lake sections have experienced increased bare ground cover compared to the baseline, with Lake K recording the greatest increase (10.2%), followed by Southern Lake (5.3%) and Lake Deborah East Major (3.3%).

4.3 MESOPHYTIC SHRUB AND TREE MONITORING

Figure 8 presents the results of the tree and shrub monitoring for 2018, compared against 2006 (baseline) and 2017 (previous year) data. Originally 19 dead trees were identified across all lakes in 2006, with the 2018 monitoring event now recording 67; an increase of five since 2017 (three in Lake K and two in Lake Deborah East Major).

There have been 48 tree deaths between the 2006 and 2018 monitoring; with 19 of these occurring at Lake K (KL1, KL2 and KL3), 24 at Lake Deborah East Major (KL7, KL8 and KL9), and five at Southern Lake (KL10, KL11 and KL12). As noted from the 2017 monitoring data (Cliffs 2018), the additional dead individuals identified in the 2018 monitoring event were a mixture of plants with previously poor condition (5-10% alive) and those with moderate to good condition in 2017 (75-80% alive). Of the three additional dead plants identified at Lake K in 2018, two were recorded with 5-10% live material in 2017, and the other was recorded with 75% live material. For the additional dead plants identified at Lake Deborah East Major in 2018, one was previously recorded as 10% alive and the other was recorded as 80% alive in 2017.

At Lake K, the 2018 monitoring recorded one fewer individual in the 76-100% live category compared with 2017, as well as one additional individual in each of the other condition categories (1-25%, 26-50% and 51-75% alive).

Monitoring at Southern Lake recorded no overall change in the number of individuals from the 76-100% condition category versus 2017. Two additional individuals at Southern Lake were recorded in the 1-25% and 51-75% categories, respectively, reflecting four fewer individuals recorded with 26-50% live material compared with 2017.

At Lake Deborah East Major, three fewer individuals were recorded in the 76-100% condition category in 2018 versus 2017, and two fewer individuals were recorded in the 51-75% category. Correspondingly, three individuals were added to the 1-25% and 26-50% condition categories relative to the 2017 monitoring event.

The data presented suggest that vegetation condition at the three lakes is following a similar trend, whereby the proportion of individuals recorded with 76-100% live material has either remained relatively stable (i.e. Southern Lake, 63.2 – 65.3%) or decrease since 2006. Whilst the proportion of tree and shrubs in this condition category at Lake K has decreased from 31.4 to 27.9% between 2006 and 2018, the equivalent proportion at Lake Deborah East Major has decreased from 69.5% to 56.1% over the same period. Similarly, the proportion of individuals recorded as dead has increased at all three sites during this period. The proportion of dead individuals increased from 15.2% to 33.7% and Lake K, from 4.1 to 14.3% and Southern Lake and from 0.8 to 18.9% at Lake Deborah East Major. In summary, although the overall condition of trees and shrubs fringing these three lakes has decreased since 2006, the evidence does not suggest that this trend is directly related to water discharged into Lake K.

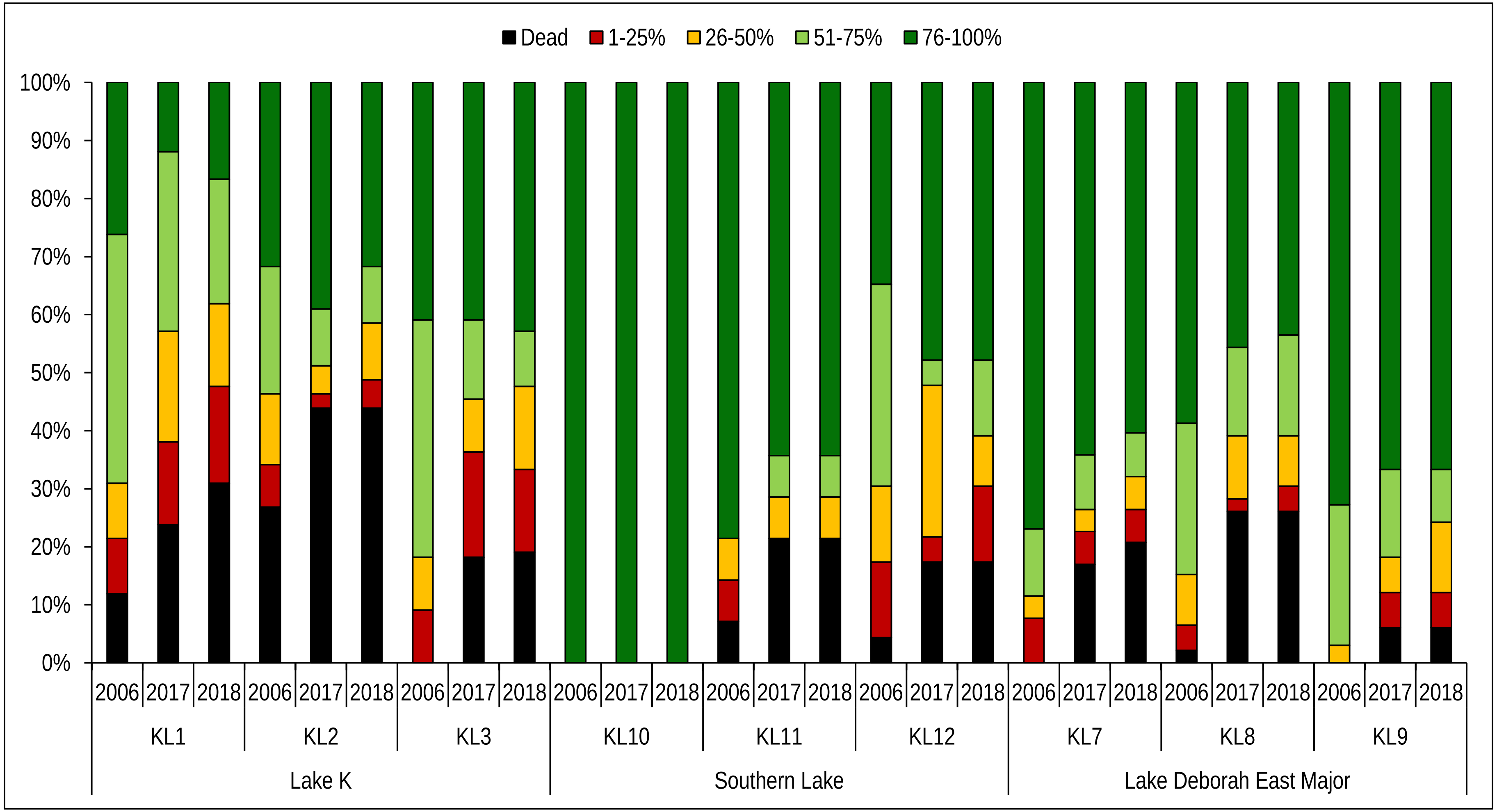

Figure 8: Condition of Tree and Shrub Species (2006 – 2018)

5. DISCUSSION

The 13 years of monitoring data collected on the condition of lake edge vegetation within the Lake Deborah system has revealed the dynamic nature of this environment. The response to, and continuing recovery from salt water intrusion into the vegetation at Lake K from an extremely high rainfall event in 1999, combined with fluctuating seasonal rainfall, are the most significant influences upon the ongoing health of this community.

The results do not currently indicate the dewatering program is having any significant effect on the fringing vegetation health. The 2018 monitoring found the vegetation at Lake K responded in a similar way to both control lakes, particularly Lake Deborah East Major which is physically separated from Lake K by the road servicing the W.A Salt Supply operations.

Dewatering inputs to Lake K ceased in February 2018 and it is highly unlikely that any further dewatering will occur in the future[2]. The value in continuing to monitor the fringing vegetation in the Lake Deborah system should be reviewed, considering (1) the lack of evidence that dewatering activities are having a continued impact upon the system and (2) dewatering has ceased and is unlikely to continue.

[2] Personal communication, Neil Smith (Environment Superintendent, MRL), 25 November 2018.

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APPENDICES

APPENDIX 1: PHOTOGRAPHIC MONITORING

Plate A1-1: Zone 1 Monitoring Photograph at KL1 Taken in 2006

Plate A1-2: Zone 1 Monitoring Photograph at KL1 Taken in 2017

Plate A1-3: Zone 1 Monitoring Photograph at KL1 Taken in 2018

Plate A1-4: Zone 4 Monitoring Photograph at KL1 Taken in 2006

Plate A1-5: Zone 4 Monitoring Photograph at KL1 Taken in 2017

Plate A1-6: Zone 4 Monitoring Photograph at KL1 Taken in 2018

Plate A1-7: Zone 1 Monitoring Photograph at KL2 Taken in 2006

Plate A1-8: Zone 1 Monitoring Photograph at KL2 Taken in 2017

Plate A1-9: Zone 1 Monitoring Photograph at KL2 Taken in 2018

Plate A1-10: Zone 4 Monitoring Photograph at KL2 Taken in 2006

Plate A1-11: Zone 4 Monitoring Photograph at KL2 Taken in 2017

Plate A1-12: Zone 4 Monitoring Photograph at KL2 Taken in 2018

Plate A1-13: Zone 1 Monitoring Photograph at KL3 Taken in 2006

Plate A1-14: Zone 1 Monitoring Photograph at KL3 Taken in 2017

Plate A1-15: Zone 1 Monitoring Photograph at KL3 Taken in 2018

Plate A1-16: Zone 4 Monitoring Photograph at KL3 Taken in 2006

Plate A1-17: Zone 4 Monitoring Photograph at KL3 Taken in 2017

Plate A1-18: Zone 4 Monitoring Photograph at KL3 Taken in 2018

Plate A1-19: Zone 1 Monitoring Photograph at KL7 Taken in 2009

Plate A1-20: Zone 1 Monitoring Photograph at KL7 Taken in 2017

Plate A1-21: Zone 1 Monitoring Photograph at KL7 Taken in 2018

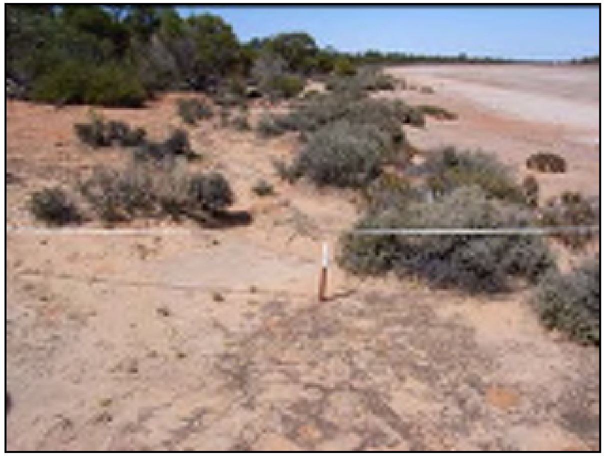


Plate A1-22: Zone 1 Monitoring Photograph at KL8 Taken in 2009

Plate A1-23: Zone 1 Monitoring Photograph at KL8 Taken in 2017

Plate A1-24: Zone 1 Monitoring Photograph at KL8 Taken in 2018

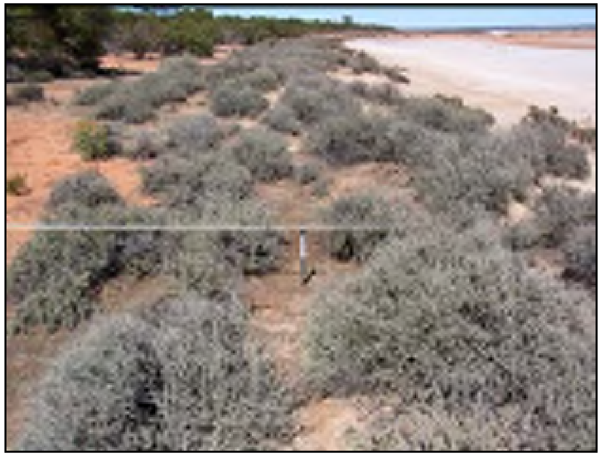


Plate A1-25: Zone 1 Monitoring Photograph at KL9 Taken in 2009

Plate A1-26: Zone 1 Monitoring Photograph at KL9 Taken in 2017

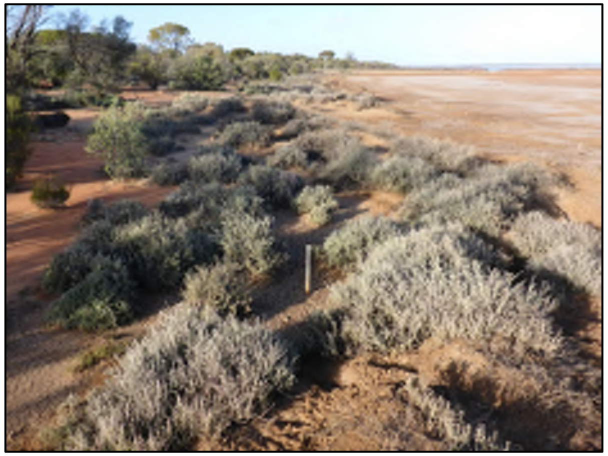


Plate A1-27: Zone 1 Monitoring Photograph at KL9 Taken in 2018

Plate A1-28: Zone 1 Monitoring Photograph at KL10 Taken in 2006

Plate A1-29: Zone 1 Monitoring Photograph at KL10 Taken in 2017

Plate A1-30: Zone 1 Monitoring Photograph at KL10 Taken in 2018

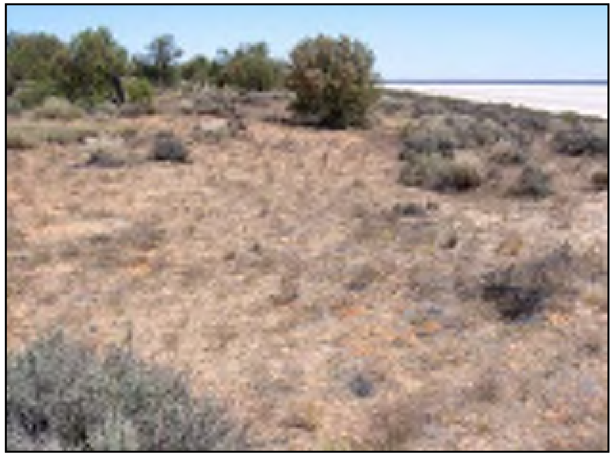


Plate A1-31: Zone 4 Monitoring Photograph at KL10 Taken in 2006

Plate A1-32: Zone 4 Monitoring Photograph at KL10 Taken in 2017

Plate A1-33: Zone 4 Monitoring Photograph at KL10 Taken in 2018

Plate A1-34: Zone 1 Monitoring Photograph at KL11 Taken in 2006

Plate A1-35: Zone 1 Monitoring Photograph at KL11 Taken in 2017

Plate A1-36: Zone 1 Monitoring Photograph at KL11 Taken in 2018

Plate A1-37: Zone 4 Monitoring Photograph at KL11 Taken in 2006

Plate A1-38: Zone 4 Monitoring Photograph at KL11 Taken in 2017

Plate A1-39: Zone 4 Monitoring Photograph at KL11 Taken in 2017

Plate A1-40: Zone 1 Monitoring Photograph at KL12 Taken in 2006

Plate A1-41: Zone 1 Monitoring Photograph at KL12 Taken in 2017

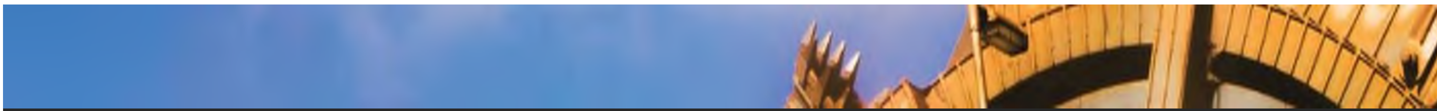
Plate A1-42: Zone 1 Monitoring Photograph at KL12 Taken in 2018

Plate A1-43: Zone 4 Monitoring Photograph at KL12 Taken in 2006

Plate A1-44: Zone 4 Monitoring Photograph at KL12 Taken in 2017

Plate A1-45: Zone 4 Monitoring Photograph at KL12 Taken in 2018

Attachment 13 – Haul Road Vegetation Monitoring Report 2018



Yilgarn Iron Ore Project

2018 TRANSPORT CORRIDOR FLORA MONITORING

Proponent:	Yilgarn Iron Pty Ltd
Address:	1 Sleat Road, Applecross, WA 6153
Postal Address:	Locked Bag 3, Canning Bridge LPO, Applecross, WA 6153
Corporate contact:	Tim Berryman
Phone:	+61 8 9329 3713
Email:	timothy.berryman@mrl.com.au

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CONTENTS

FIGURES

TABLES

1 Introduction

In 2018 Mineral Resources Limited (MRL) acquired Cliffs Asia Pacific Iron Ore Pty Ltd.'s (Cliffs) Yilgarn Operations. This includes the mining of iron ore from open cut pits at the Koolyanobbing Range, Mt Jackson Range, Windarling Range and Deception, ore processing at Koolyanobbing, and road and rail transport between these operations and the Port of Esperance where the processed ore is exported to international customers.

MRL continues to the implement the Flora and Vegetation Management Plan developed by Cliffs, one of a series of plans that outlines the management of environmental aspects of the operations. The purpose of the Flora and Vegetation Management Plan is to outline the management actions that will be implemented to address the environmental risks and obligations associated with flora and vegetation; including potential impacts and management actions relevant to transport operations and the maintenance of the haul roads from Koolyanobbing to Windarling and Mt Jackson.

Transport operations and haul road maintenance have the potential to result in dust emissions and dust-related impacts on vegetation adjacent to the haul road. Haul road maintenance and dust suppression activities have proven effective in contributing to a reduction in the potential dust emissions from haul road use. The Flora and Vegetation Management Plan outlines an annual monitoring program that is used to identify any impacts on the native vegetation adjacent to the haul road.

The objective of this report is to document and discuss the results of the 2018 vegetation monitoring and compare these with the 2016, 2017 (previous years) and 2011 (initial monitoring) results.

2 Methodology

The 2018 monitoring was conducted on the 24th and 25th of August 2018 and involved revisiting the 27 plots established during the 2011 monitoring. In 2011, these 20 x 20m plots were established at nine different locations along the haul road; with one plot located adjacent to either side of the haul road (East/West for the Koolyanobbing-Windarling haul road, North/South for the Mt Jackson haul road) and one plot located over 100m away from the haul road, used as a control. The location of these plots is shown in Figure 2.1.

All plots were marked with a metal fence dropper at each corner during initial establishment (2011). At each 20m x 20m plot, the following information was recorded during each year of monitoring:

- Plot Identification
- Monitoring Date
- Personnel conducting monitoring
- GPS location (GDA94) taken from NW corner of plot
- Distance of plot from haul road (10m or 100m)
- Landform and soil type
- Photographic record taken from NW corner of plot
- Vegetation Type

FIGURE 2.1: LOCATION OF HAUL ROAD MONITORING PLOTS.

2.1 Vegetation Condition Monitoring

Within each plot, the condition of the vegetation was ranked using the Keighery (1994) scale, as outlined in Table 2.1 : Summary of Vegetation Condition Scale as developed by Keighery (1994)

TABLE 2.1 : SUMMARY OF VEGETATION CONDITION SCALE AS DEVELOPED BY KEIGHERY (1994)

Code	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered; obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as “parkland cleared’ with the flora comprising weed or crop species with isolated native trees or shrubs.

2.2 Individual Species Monitoring

Each individual species tagged in 2011 (up to six individual plants within each 20m x 20m plot) was revisited and given a health and dust ranking as per the categories shown in Table 2.2 and Table 2.3. General comments on the health of other individuals and species were recorded where necessary.

TABLE 2.2: HEALTH CATEGORIES USED FOR MONITORING SELECTED FLORA INDIVIDUALS.

Rating	Description
0	Dead
1	1-25% of foliage alive
2	26-50% of foliage alive
3	51-75% of foliage alive
4	76-100% of foliage alive

TABLE 2.3: DUST CATEGORIES USED FOR MONITORING SELECTED FLORA INDIVIDUALS.

Rating	Description
0	No Dust
1	1-25% of foliage covered dust
2	26-50% of foliage covered dust
3	51-75% of foliage covered dust
4	76-100% of foliage covered in dust

During the 2017 monitoring, chlorophyll fluorescence (Fv/Fm) was included as a monitoring parameter for the first time. Each individual that could be accessed (tall trees/shrubs were excluded when the leaves could not be reached) had an index of chlorophyll fluorescence reading taken using a pocket PEA unit. Using information gained from fluorescence measurements, samples may be screened effectively for particular types of stress factors which limit the photosynthetic performance of the sample (Hansatech 2006). A clip was attached to a live leaf of each accessible individual, and a reading taken when the phyllodes were suitably dark adapted. An index of chlorophyll fluorescence was then measured with the PEA unit and recorded. A total of 126 individuals were measured for chlorophyll fluorescence. This parameter was again measured and recorded during the 2018 monitoring.

3 Rainfall

The total rainfall recorded by both Koolyanobbing and Windarling for the 12 months prior to the 2018 monitoring (Aug 2017 – July 2018) is presented in Figure 3.1. Also displayed is the total rainfall recorded in the 12 months prior to the 2017 and 2016 (previous 2 years) monitoring as well as 12 months prior to the 2011 (initial) monitoring (Dec 2010 – Nov 2011) (BoM 2018). The 12 month average annual rainfall for both Windarling and Koolyanobbing is also shown in

Figure 3.1.

The 2018 monitoring season recorded a total rainfall of 298.3mm at Koolyanobbing and 258.8mm at Windarling. Both Koolyanobbing and Windarling recorded decreased rainfall of 17.8mm and 15.1mm respectively from the previous monitoring period and significantly less than the 2011 season (353.7mm and 342.3mm respectively). The rainfall received at Koolyanobbing during the 2018 season was above the annual average of 283.5mm; whereas annual rainfall recorded at Windarling was below the annual average of 282.3mm.

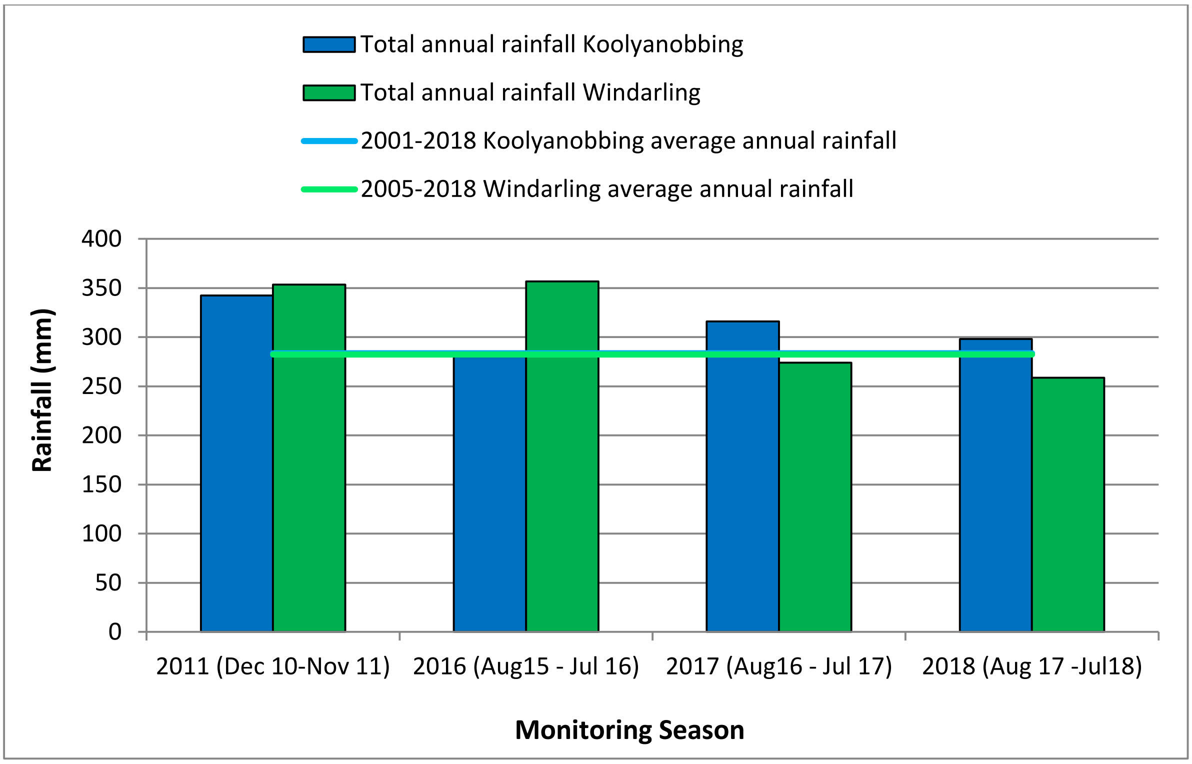

FIGURE 3.1: TOTAL RAINFALL RECORDED PRIOR TO EACH MONITORING SEASON AND AVERAGE ANNUAL RAINFALL RECORDED AT KOOLYANOBBING AND WINDARLING (BOM 2018).

4 Results

4.1 Vegetation Condition

Appendix 1 presents a photographic record of each plot. The results of the Vegetation Condition monitoring are shown in Table 4.1. All plots were found to be in healthy condition for all years of monitoring (2011-2018), ranked in 'Good' to 'Excellent' categories as defined by Keighery (1994). The 2018 monitoring found 14 of the 27 (52%) plots remained in the same condition when compared to the 2017 monitoring; whilst the remaining plots decreased. Compared with the initial monitoring (2011) data, the 2018 monitoring found 13 of the plots (48%) to be in a similar or healthier condition to when monitoring began.

TABLE 4.1: VEGETATION CONDITION MONITORING RESULTS FOR 2018 AND COMPARISON AGAINST 2017 (PREVIOUS YEAR) AND 2011 (INITIAL) RESULTS

Plot	Vegetation Ranking 2018	Change from 2017-2018	Change from 2011 - 2018
1 (West)	Very Good	-	-
2 (Control)	Excellent	-	Increase
3 (East)	Very Good	-	Decrease
4 (East)	Very Good	Decrease	Decrease
5 (Control)	Very Good	Decrease	Decrease
6 (West)	Very Good	Decrease	Decrease
7 (West)	Very Good	-	-
8 (Control)	Good	Decrease	Decrease
9 (East)	Good	Decrease	Decrease
10 (West)	Good	Decrease	Decrease
11 (East)	Very Good	Decrease	-
12 (Control)	Good	Decrease	Decrease
13 (West)	Good	Decrease	Decrease
14 (Control)	Very Good	-	-
15 (East)	Very Good	-	-
16 (West)	Very Good	-	Decrease
17 (Control)	Very Good	-	-
18 (East)	Very Good	-	-
19 (South)	Very good	Decrease	Decrease
20 (Control)	Very Good	Decrease	Decrease
21 (North)	Good	Decrease	Decrease
22 (South)	Very Good	-	-

Plot	Vegetation Ranking 2018	Change from 2017-2018	Change from 2011 - 2018
23 (Control)	Excellent	-	Increase
24 (North)	Good	Decrease	Decrease
25 (North)	Very Good	-	-
26 (Control)	Very Good	-	-
27 (South)	Very Good	-	-

Figure 4.1 displays the percentage of plots ranked in each vegetation condition category based on location from haul road (i.e. east of haul road, west of haul road, control plots only etc.) for the 2011, 2016, 2017 and 2018 monitoring periods.

The vegetation condition of plots decreased at all locations between the 2017 and 2018 monitoring, including the controls (Figure 4.1). However, all plots were still recorded in the top three health categories (Excellent, Very Good and Good).

When all plots adjacent to the haul road were compared with all control plots, those adjacent to the haul road were found to be in slightly poorer condition during the 2018 monitoring. Vehicle and animal tracks were observed which would suggest public access and/or mustering operations.

Between 2011 (initial monitoring) and 2018, all plots have seen a decrease in condition (Figure 4.1).

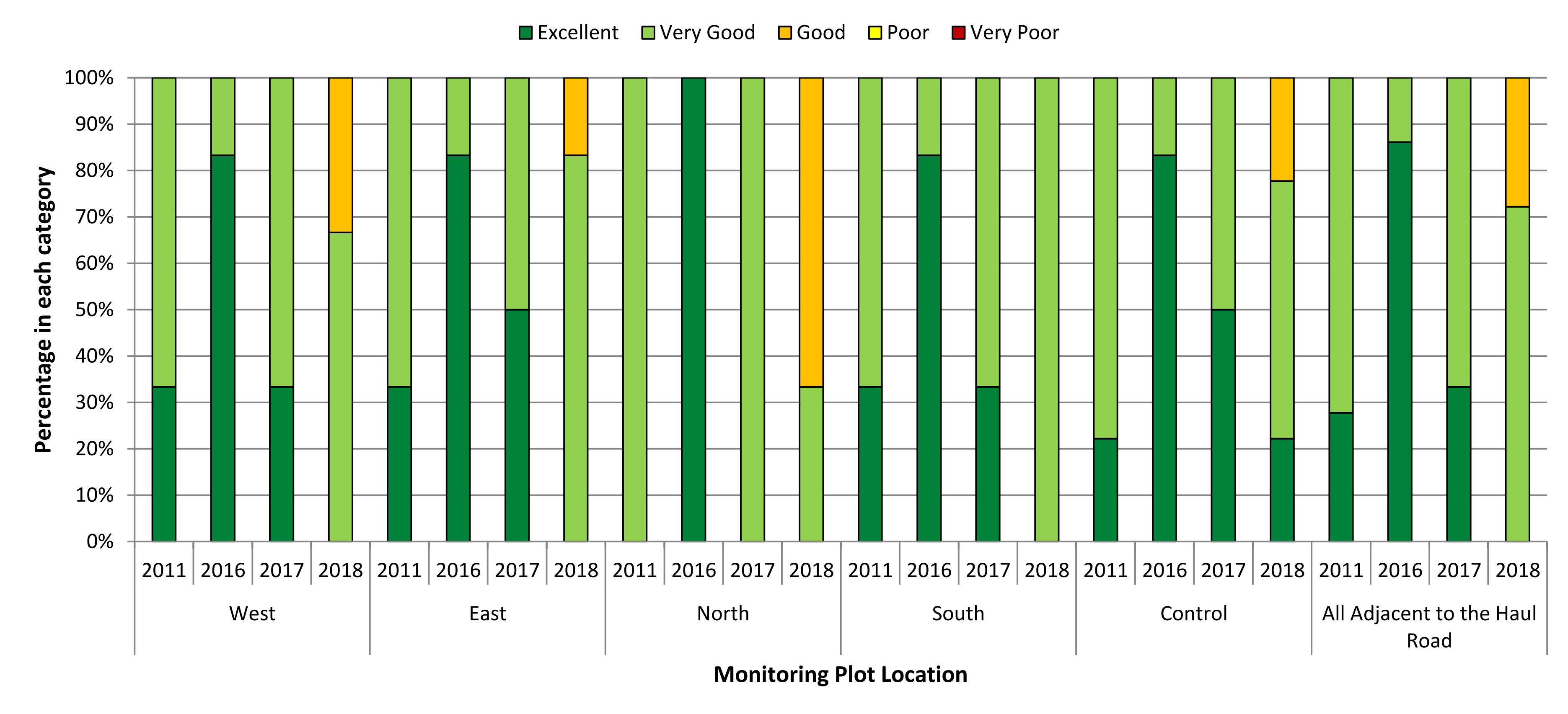

FIGURE 4.1: PERCENTAGE OF PLOTS RANKED IN EACH VEGETATION CATEGORY, BASED ON LOCATION IN RELATION TO THE HAUL ROAD, FOR THE 2011 (INITIAL), 2016 AND 2017 (PREVIOUS YEARS) AND 2018 (CURRENT YEAR) MONITORING.

4.2 Individual Species Monitoring

4.2.1 Health Monitoring

The results of the health monitoring on individual species within plots is presented in Figure 4.2 for the 2011 (initial), 2016, 2017 (previous years) and 2018 monitoring periods. All individuals that were recorded as dead over two consecutive monitoring periods were replaced as per the monitoring guidelines. The 2018 monitoring found individuals both adjacent to the haul road and in the control locations all have shown a marked increase in condition since the 2017 monitoring (10% and a 17.4% increase respectively).

The least healthy plots adjacent to the haul road in 2018, were located south of the haul road (to Mt Jackson) (53% of individuals in the 75-100% category), whilst the healthiest locations were plots to the east of the haul road (80% of individuals in the 75-100%). The control plots also increased in health, from previous monitoring events. 60% of individuals recorded in the 75-100% category in 2017 to 77.4% in 2018.

Individuals ranked in all 5 categories were only recorded in the control plots in 2018 (Figure 4.2).

Overall, individuals adjacent to the haul road were found to be in a similar condition to individuals in the control plots during the 2018 monitoring. In 2018, 72% of individuals adjacent to the haul road were ranked in the '76-100% of foliage alive' category, compared with approximately 62.3% in 2017. The health of individuals has improved from the previous year in both control plots and those adjacent to the haul road. The overall condition of individuals adjacent to the haul road is considered to be healthy (Figure 4.2).

4.2.2 Dust Monitoring

The results of the dust monitoring on individual species within plots is presented in Figure 4.3 for the 2011 (initial), 2016, 2017 (previous years) and 2018 monitoring. The 2018 monitoring found 98% of individuals ranked in the no dust category, and 8% ranked in the '1-25% of foliage covered in dust' category. Dust levels improved at all locations since the 2017 monitoring (Figure 4.3). The dustiest locations in 2018 were west of the haul road, where 14% of individuals recorded '1-25% of foliage covered in dust', however, 86% remained dust free. This differs from the 2017 monitoring event where plots located south of the haul road where found to be the dustiest (Figure 4.3).

Dust levels have decreased at all locations compared to when monitoring began in 2011. As is expected, individuals located adjacent to the haul road were found to be dustier than those in the control areas, although the 2018 monitoring still recorded approximately 92% of these individuals to be dust free.

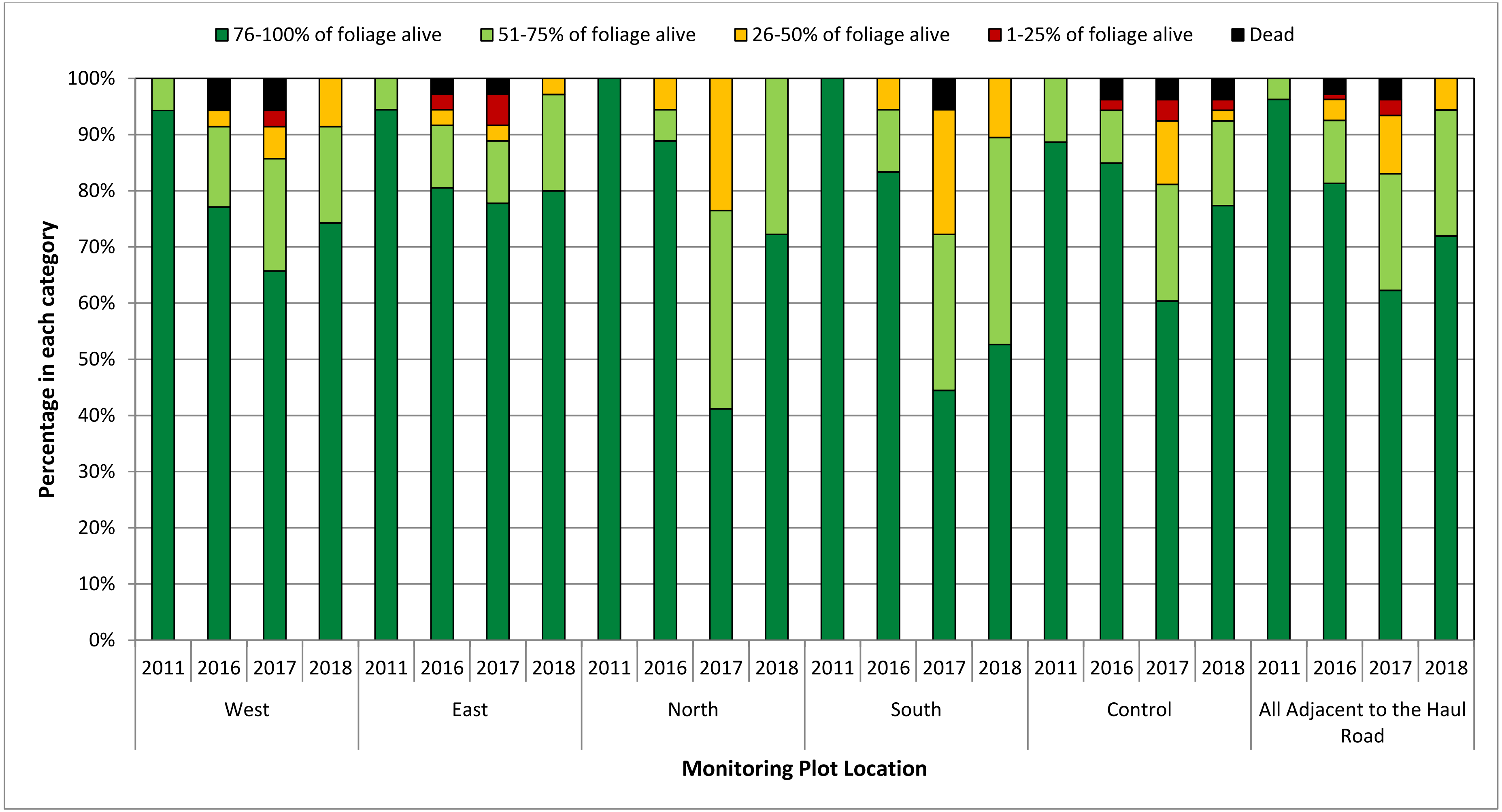

FIGURE 4.2: HEALTH MONITORING RESULTS OF INDIVIDUAL SPECIES, BASED ON LOCATION RELATIVE FROM THE HAUL ROAD FOR 2011 (INITIAL), 2016, 2017 (PREVIOUS YEARS) AND 2018 (CURRENT YEAR) MONITORING.

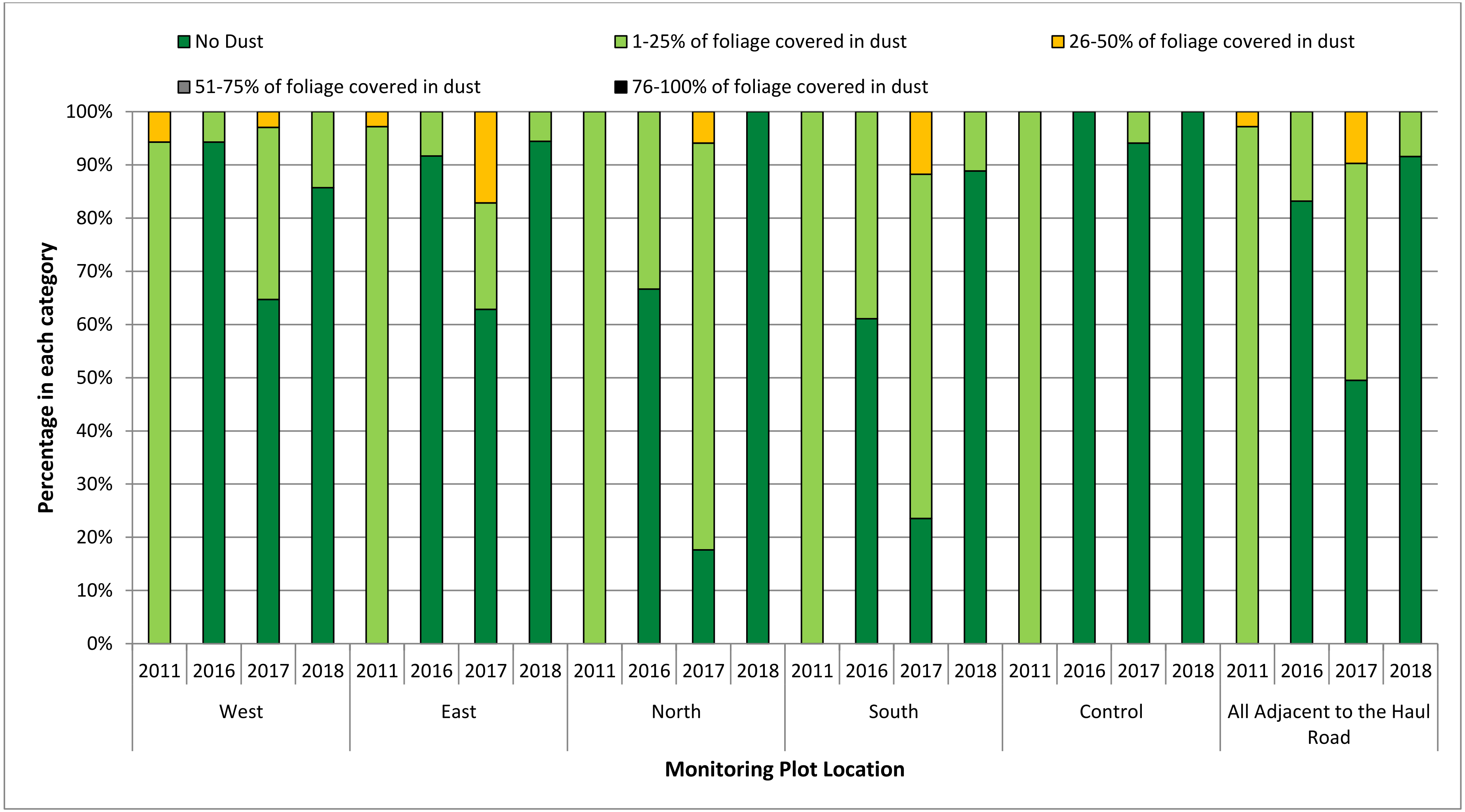

FIGURE 4.3: DUST MONITORING RESULTS OF INDIVIDUAL SPECIES, BASED ON LOCATION RELATIVE TO THE HAUL ROAD FOR 2011 (INITIAL), 2016, 2017 (PREVIOUS YEARS) AND 2018 (CURRENT YEAR) MONITORING.

4.2.3 Chlorophyll Fluorescence Monitoring

Chlorophyll fluorescence (Fv/Fm) was included as a monitoring parameter for the first time during the 2017 monitoring. Figure 4.4 presents the average chlorophyll fluorescence for each monitoring location with respect to the haul road and compares it to data from the previous monitoring period. Average chlorophyll fluorescence was similar across all locations, ranging from 0.70 (west of haul road) to 0.76 (north of haul road) and indicates an overall increase in vegetation health from the 2017 monitoring event.

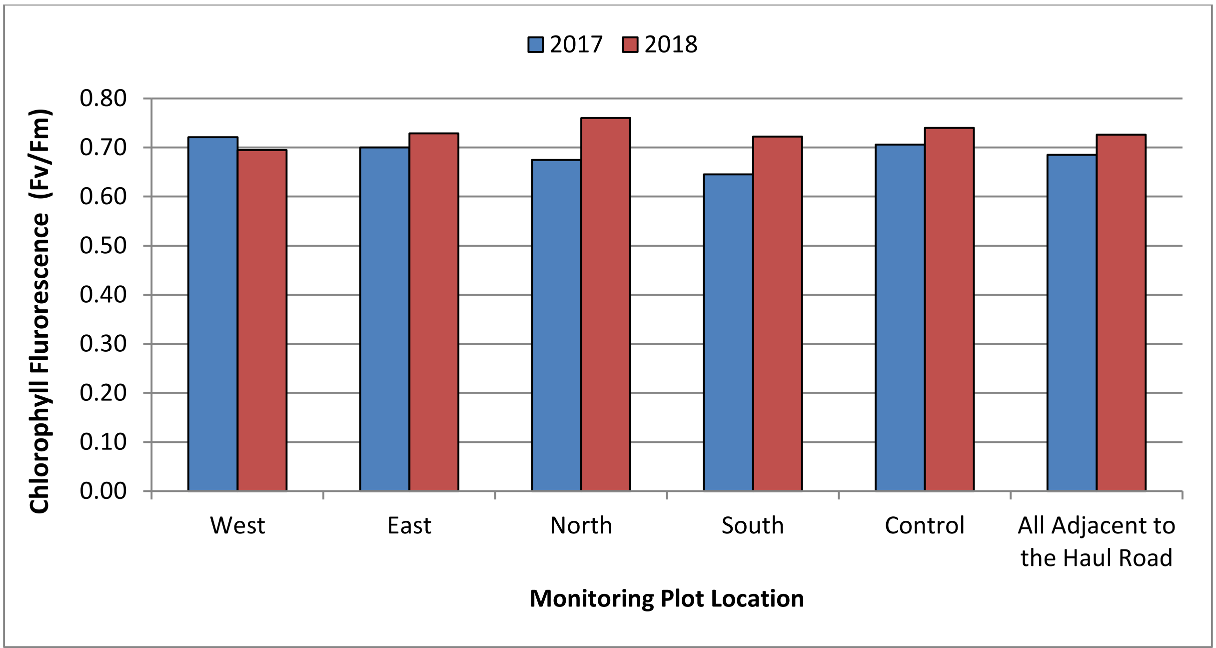

FIGURE 4.4: AVERAGE CHLOROPHYLL FLUORESCENCE BASED ON LOCATION RELATIVE TO THE HAUL ROAD FOR THE 2017 AND 2018 MONITORING PERIODS.

5 Discussion and Conclusions

The results of the 2018 monitoring found the vegetation adjacent to the haul road to be in a healthy condition even though there was a slight decline in plot condition. About half (48%) were in a similar or better condition than when monitoring begun in 2011. The transition of ownership from Cliffs to MRL saw a marked reduction in haul road traffic which may have increased the prevalence of large herbivores (evidence of grazing within the plots). Vehicle and animal tracks (mustering operations and/or public access) were also noted through some of the monitoring locations. Minor fluctuations in condition are therefore considered to be a result of grazing. It does not currently appear that haul road activities are having an effect on the condition of vegetation adjacent to the haul road. Future monitoring in 2019 and beyond will help to quantify further the health of the vegetation in these areas.

The results of the individual health monitoring found the flora remained in a healthy condition, with those adjacent to the haul road in a similar (although for some slightly healthier) condition to those in the control areas. All individuals that were recorded as dead over two consecutive monitoring periods were replaced as per the monitoring guidelines. It appears that on average individuals within all plots adjacent to the haul road have seen an improvement in health. There was no significant variation in health based on plot location in relation to the haul road, all plots showed an improvement as did the control plots. There was still however a reduction in plant health when compared to the 2011 monitoring period in which Koolyanobbing and Windarling both received above average rainfall in the twelve months preceding the monitoring event. The 2019 monitoring will provide further insight into whether an improvement continues, and whether individual health results are related to natural or dust related factors.

The 2018 monitoring found all individuals adjacent to the haul road had significantly less dust loading when compared to 2016, 2017 and when monitoring began in 2011. The decrease in dust loading is likely the result of significant rainfall events just prior to monitoring, resulting in dust being washed from the phyllodes. There is no correlation between dust levels and health of individuals, with the majority of less healthy individuals found to be dust free and those with the highest chlorophyll fluorescence readings recording some dust coverage.

The 2018 chlorophyll fluorescence monitoring recorded an average Fm/Fv value of between 0.70 to 0.76 for all locations. Ritchie (2006) and Percival (2005) suggest values below 0.6 indicate plant stress. It is therefore concluded that the vegetation adjacent to the transport corridor is in a healthy condition and has shown some improvement since the 2017 monitoring event.

In conclusion, the 2018 monitoring found the vegetation and individuals to be in a healthy condition with minimal or no dust cover. Vegetation adjacent to the haul road was found to be in a similar condition to the control plots with an improvement in individual health since the last monitoring period. However, there appears to be a slight decline from when monitoring began in 2011. Currently, it does not appear that haul road activities are negatively impacting the native vegetation adjacent to the haul road. The amount and consistency of rainfall throughout the year, and grazing pressure appear to be the main factors affecting vegetation condition and health. Monitoring will continue to be conducted on an annual basis and the results analysed for potential impacts on native vegetation as a result of haulage activities.

5.1 Comparison of Results against Trigger Criteria

The Flora and Vegetation Management Plan (2016) outlines trigger criteria that require further reporting and contingency actions. The following section compares the results of the 2018 monitoring against the relevant trigger criteria.

1. ***Annual monitoring indicates a decline of greater than 15% in plant condition relative to the previous year; and rainfall is >150mm between annual sampling dates (i.e. the change is unlikely to be a result of drought conditions).***

   The 2018 monitoring found individuals both adjacent to the haul road and in the control locations all have shown a marked increase in condition since the 2017 monitoring (10% and a 17.4% increase respectively) as discussed in Section 4.2.1. Therefore, this trigger criterion has not been met.

2. ***Annual monitoring indicates a mortality of greater than 10% of the sampled population since the previous year and rainfall is >150mm between annual sampling dates.***

   No new deaths were recorded during the 2018 monitoring as is evident in Figure 4.2. This therefore indicates that this trigger criterion has not been met.

3. ***Annual monitoring indicates a consistent pattern of decline in population numbers over a longer time scale (2+ years).***

   Results of monitoring has shown that there has not been a consistent pattern of decline. Vegetation seems to be in a state of natural regeneration even in the face of declining rainfall, with several individuals showing recovery from previous years (Section 4.2.1).

4. ***Annual monitoring indicates a spatial pattern of decreasing plant condition and/or higher mortality that may be related to proximity to mining operations*.**

   All plots were found to be in healthy condition for all years of monitoring (2011-2018), ranked in 'Good' to 'Excellent' categories as defined by Keighery (1994). The 2018 monitoring found 14 of the 27 (52%) plots remained in the same condition when compared to the 2017 monitoring; whilst the remaining plots had minor decreases. Decreases in condition were observed in both the control plots and those adjacent to the haul road.

   The individual monitoring results show that on average, individuals within all plots adjacent to the haul road have seen an improvement in health. There was no significant variation in health based on plot location in relation to the haul road, all plots showed an improvement as did the control plots. There also appears to be no correlation between dust levels and health of individuals, with the majority of less healthy individuals found to be dust free and those with the highest chlorophyll fluorescence readings recording some dust coverage.

6 References

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Keighery, B. (1994) *Bushland Plant Survey: A Guide for Community Surveys*. Wildflower Society of Western Australia, Perth WA.

Percival (2005) The use of Chlorophyll Fluorescence to Identify Chemical and Environmental Stress in Leaf Tissue of Three Oak (QUERCUS) Species. Journal of Arboriculture 31 (5): September 2005. p215.

Ritchie (2006) Chlorophyll Fluorescence: What is it and What do the Numbers Mean? National Proceedings Forest and Conservation Nursery Associations – 2005. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 160p.

7 Appendix 1

Photographic Monitoring Records



Photos 1-3: Plot 01 2011 (left), 2017 (centre) and 2018 (right)



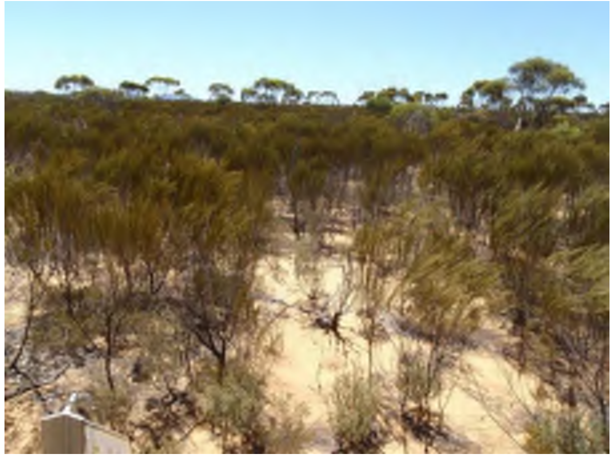
Photos 4-6: Plot 02 2011 (left), 2017 (centre) and 2018 (right)



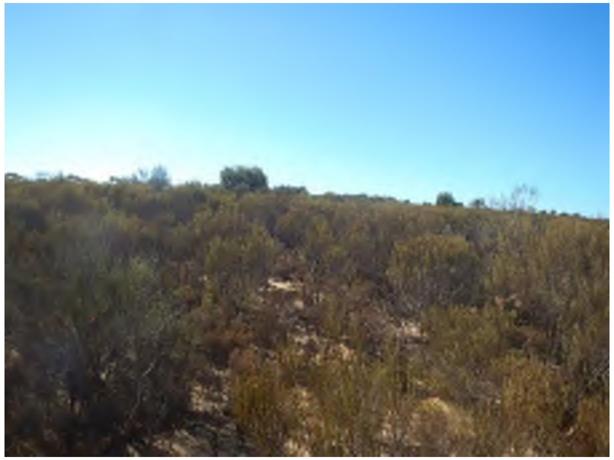
Photos 7-9: Plot 03 2011 (left), 2017 (centre) and 2018 (right)



Photos 10-12: Plot 04 2011 (left), 2017 (centre) and 2018 (right)



Photos 13-15: Plot 05 2011 (left), 2017 (centre) and 2018 (right)


Photos 16-18: Plot 06 2011 (left), 2017 (centre) and 2018 (right)



Photos 19-21: Plot 07 2011 (left), 2017 (centre) and 2018 (right)



Photos 22-24: Plot 08 2011 (left), 2017 (centre) and 2018 (right)



Photos 25-27: Plot 09 2011 (left), 2017 (centre) and 2018 (right)



Photos 28-30: Plot 10 2011 (left), 2017 (centre) and 2018 (right)



Photos 31-33: Plot 11 2011 (left), 2017 (centre) and 2018 (right)



Photos 34-36: Plot 12 2011 (left), 2017(centre) and 2018 (right)

Photos 37-39: Plot 13 2011 (left), 2017 (centre) and 2018 (right)

Photos 40-42: Plot 14 2011 (left), 2017(centre) and 2018 (right)



Photos 43-45: Plot 15 2011 (left), 2017 (centre) and 2018 (right)



Photos 46-48: Plot 16 2011 (left), 2017 (centre) and 2018 (right)



Photos 49-51: Plot 17 2011 (left), 2017 (centre) and 2018 (right)



Photos 52-54: Plot 18 2011 (left), 2017 (centre) and 2018 (right)



Photos 55-57: Plot 19 2011 (left), 2017 (centre) and 2018 (right)



Photos 58-60: Plot 20 2011 (left), 2017 (centre) and 2018 (right)



Photos 61-63: Plot 21 2011 (left), 2017(centre) and 2018 (right)



Photos 64-66: Plot 22 2011 (left), 2017(centre) and 2018 (right)

Photos 67-69: Plot 23 2011 (left), 2017 (centre) and 2018 (right)

Photos 70-72: Plot 24 2011 (left), 2017 (centre) and 2018 (right)

Photos 73-75: Plot 25 2011 (left), 2017 (centre) and 2018(right)

Photos 76-78: Plot 26 2011 (left), 2017 (centre) and 2018(right)

Photos 79-81: Plot 27 2011 (left), 2017 (centre) and 2018 (right)

Attachment 14 – Restricted Areas Windarling

Restricted areas and management of *Tetratheca paynterae* subsp. *paynterae* at the Windarling Range

Figure 1: Photo locations in relation to Area A and B. No disturbance carried out in Area A or B.

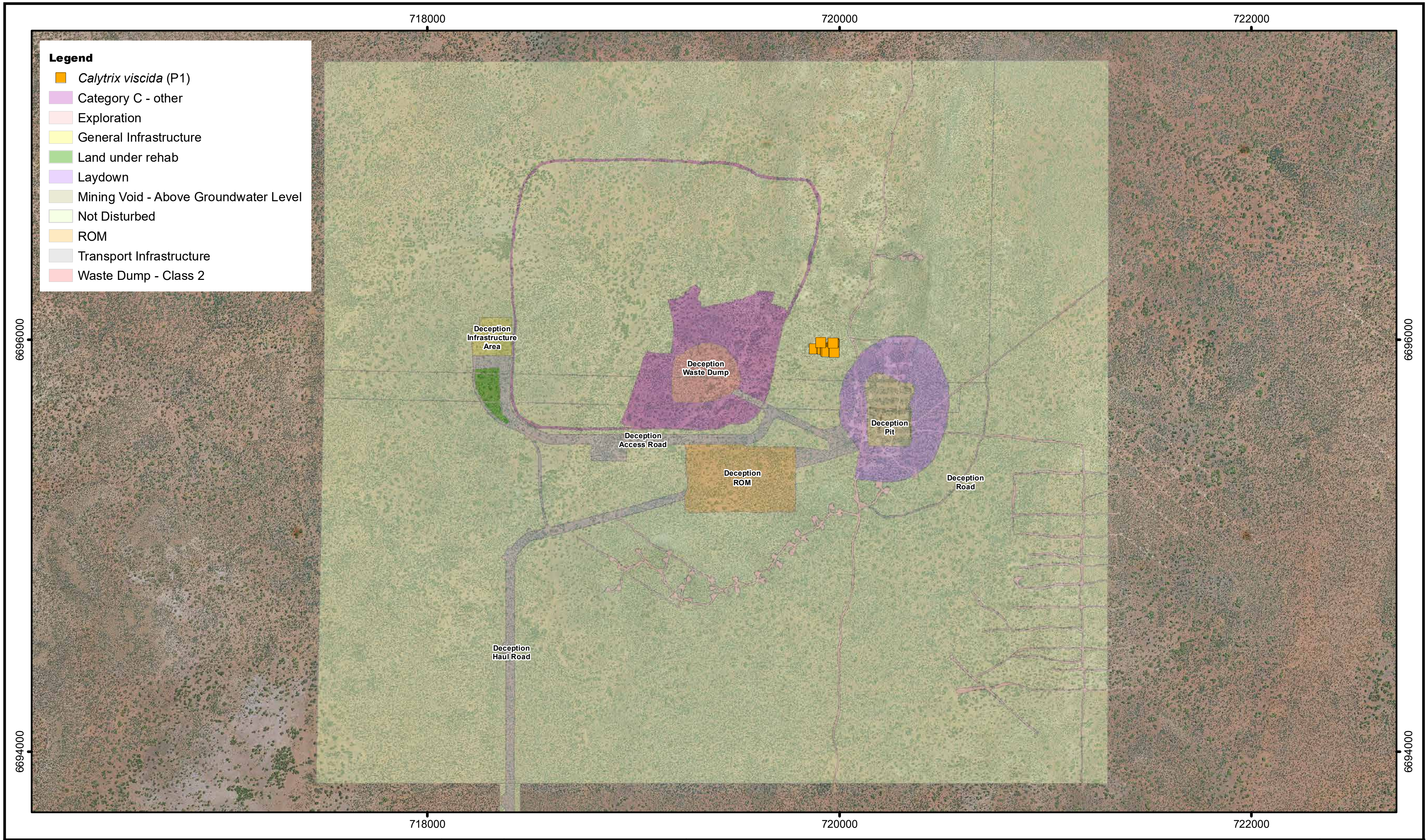
Figure 2: Photo point A looking north towards Area A (south face of the Windarling Ridge)

Figure 3: Photo point B looking west at north face of Area A on the Windarling Ridge.

Figure 4: Signage restricting access to Area A and B.

Figure 5: Signage at various locations restricting access to Area A and B.

Attachment 15 – Deception Disturbance Area



Notes:

N

0 300 600 m

Scale: 1:25,000
MGA94 (Zone 50)

CAD Ref: a2645_F005_01

Date: April 2019 | Rev: A | A4

MINERAL RESOURCES

Author: N. Smith

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

Yilgarn Operations

Deception Mine Operations

Calytrix viscida (P1)

Figure: 1

Attachment 16 – Annual Malleefowl Nest Mound Monitoring Report 2018

Malleefowl Nest Mound Annual Monitoring Mt Jackson, October 2018

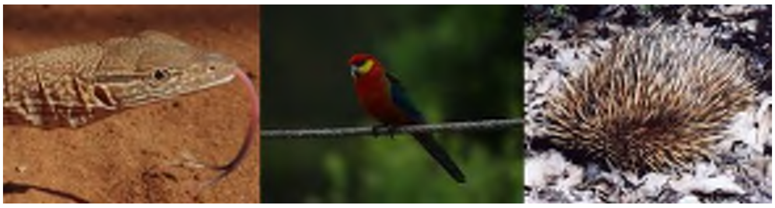
Prepared for: Mineral Resources Ltd

By BIOSTAT Pty Ltd

April 2019

BIOSTAT Pty Ltd

For when experience counts



BIOSTAT Pty Ltd

ABN 87 092 767 032
39 Doris St
North Perth Western Australia 6006
Ph: +61 8 6460 2455 Fax: +61 8 9443 8940
www.biostat.com.au consulting@biostat.com.au

This document has been prepared for double sided printing.

REVISION SCHEDULE

Rev. No.	Date	Description	Prepared/ Approved By
1	12/2/18	First draft release for review by Mineral Resources	EGC
2	22/3/2019	Draft with additional information relating to MRL commitments	EGC
3	8/4/2019	Draft incorporating results of discussions with Neil Smith and clarification of likely commitments by MRL. Includes a review of the monitoring program for inclusion into the Adaptive Management Experiment. Recommendations have not been altered.	EGC

STATEMENT OF LIMITATIONS

This report and the associated services performed by BIOSTAT Pty Ltd were undertaken to satisfy the requirements of Mineral Resources Ltd (the 'Client') as set out in the scope of services defined in the contract agreed to between BIOSTAT Pty Ltd and the Client. That scope of services was defined by the request of the Client, by the time and budgetary constraints imposed by the Client, the availability of information and by the availability of access to the site defined by the Client.

BIOSTAT Pty Ltd derived the data in this report primarily from site observations, information provided by the Client and an examination of records in the public domain as described in the scope of services. The passage of time, manifestation of latent conditions, additional information or impacts of future events may require further consideration of the Project and its scope, and may require further subsequent data analysis and re-evaluation of the findings, observations and conclusions expressed in this report.

BIOSTAT Pty Ltd has relied upon and presumed accurate certain information (or absence thereof) relative to the site provided by government officials and authorities, the Client and others identified herein, in the preparation of this report. BIOSTAT Pty Ltd has not attempted to verify the accuracy or completeness of any such information except where stated otherwise in this report.

No warranty or guarantee, whether express or implied, is made with respect to the data reported or to the findings, observations and conclusions expressed in this report. Further, such data findings, observations and conclusions are based solely upon site conditions and information provided by the Client at the time of the investigation.

This report has been prepared on behalf of and for the exclusive use of the Client, and is subject to and issued in connection with the provision of the agreement between BIOSTAT Pty Ltd and the Client. BIOSTAT Pty Ltd accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

(The 'Project' is defined as the scope of services as set out in the contract and agreed to by BIOSTAT Pty Ltd and the Client.)

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EXECUTIVE SUMMARY

The 2018 survey was the sixth event in a specifically designed monitoring program, Impact Assessment Monitoring (IAM), to investigate the impact of mine activity on malleefowl mound activity. The survey also incorporated an additional set of mounds as part of the annual 3-year monitoring cycle usually undertaken by MRL personnel. A total of 153 mounds were visited and monitored for this survey.

The 2018 survey confirmed the findings of previous five surveys indicating no significant relationship between mound activity and the distance from the main sources of mine activity, i.e., J1 Pit. Mound activity has only fluctuated slightly over the 6 years of the IAM program. There was a substantial drop in 2014 and 2015 with a spike in activity in 2016.

The data collected for IAM does not trigger the first of these criteria although there was a large drop in mound activity from 2014 to 2015 of 31.8%. This was followed by an increase in 2016 with greater levels of mound activity. There has been a small annual decrease in mound activity within the IAM since 2016. However, it is difficult to determine the causal factors as this drop could be associated with seasonal conditions (e.g., rainfall and temperatures), changes in mound usage patterns (i.e., use of mounds that are not surveyed) or even impacts from such management actions as introduced predator control.

The second management action trigger relies on data obtained from surveys and from the sightings register. This criterion was not triggered as successive drops were only noted in two years (2017 and 2018) and not three. However, sightings register data collates opportunistic sightings of animals by mine personnel in their day to day activities. These registers cannot be considered as wholly representative of malleefowl activity within the area as the quality of the data is highly variable. The register depends on the identification skills of all personnel, their diligence in reporting the information, and the training provided to encourage personnel to participate in the register. The inconsistencies in the quality of the data present a problem in the inclusion of this information in criteria for management of the species. It is strongly recommended that the observation register be maintained as an anecdotal data collection rather than a critical component of criteria determination.

The IAM survey was specifically designed to test the last criteria of the Yilgarn Fauna Management Plan. The design of the survey considered the level of activity as a measure of distance from the main point of mining operations, J1 pit, on the western end of the Mt Jackson range. The data consistently shows no relationship between distance from J1 pit and mound activity.

What the IAM program has highlighted is that further work is needed to understand dynamics of the population in the Mt Jackson area. The establishment of the Adaptive Management Experiment (AME) provides the impetus to redesign the monitoring program to allow for a more focused investigation that will feed directly into the management of the species.

The inclusion of additional mound data as part of the IAM survey highlighted the value of a larger sample size in the interpretation of malleefowl population dynamics. The AME provides for that increase in the sample size. There is a need to increase the understanding of factors that directly impact on the population, especially where those factors can be managed and mitigated.

The major constraint in the research of malleefowl is their longevity. It is necessary to consider any research into this species will always be mid- and long-term propositions. The continued annual long-term monitoring of mound activity via AME is more likely to determine management needs of this species. The value of AME is that with annual data collected from the same mounds, it is likely that any changes may be detected earlier than the current 3-year monitoring cycle system. Any results can be considered and integrated into management of malleefowl at Mt Jackson.

The opportunity to engage in AME will allow for a more focused approach to malleefowl monitoring in the Mt Jackson area that should provide a greater level of certainty from the information that is collected. Furthermore, the standardisation of methods can provide a greater understanding of the population dynamics of the Mt Jackson malleefowl population. The incorporation of predator monitoring may also provide some useful information on the impacts of predators on malleefowl and the effectiveness of predator control measures.

Irrespective of the recommendations made here, the priority of the monitoring program must be to provide information that can be integrated into the adaptive management of the Mt Jackson malleefowl population.

1 INTRODUCTION

This report describes the continuation of the Impact Assessment Monitoring Program (IAM) established in 2013 (BIOSTAT Pty Ltd 2013) to investigate the impact of mine activity of malleefowl (*Leipoa ocellata*) in the Mt Jackson area. This is the sixth year of the monitoring program (BIOSTAT Pty Ltd 2014, 2015a, 2015b, 2017, 2018) and was carried out in October 2018. In conjunction with the IAM, this report will also discuss the results of the 3-Year Monitoring Cycle (Y3M) carried out during the same event.

Malleefowl are medium-sized birds of the family Megapodidae once common over much of southern Australia. Since European settlement this species has suffered a significant decrease in range due to anthropogenic impacts, such as introduced predators and herbivores, increased fires, habitat destruction and hunting.

Malleefowl now inhabit semi-arid shrublands and low woodlands dominated by Mallee-eucalypts and/or acacias in Western Australia. They create large mounds of soil and prefer sandier habitats. The selection of mound sites is dependent on regional, seasonal and microhabitat factors. In more arid zones Malleefowl tend to use exposure to sunlight and aspect of the mound location as selection factors, whereas in the Mallee of South-Eastern Australia, they select areas with near-continuous canopy and plentiful leaf litter (Benshemesh 2007). Similarly, mounds in more arid zones are generally constructed out of soil and pebbles and can contain some or very little vegetative material to assist in incubation through its decomposition (Jones & Goth 2008). In areas where there is substantial leaf litter, the vegetative content of mounds is substantially higher, as their decomposition aids in temperature maintenance. Malleefowl are generalist herbivores with locality specific diets (Reichelt & Jones 2008).

Malleefowl are listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) and Schedule 3 of the Western Australian *Biodiversity Conservation Act 2016* (*BC Act*).

Data collected since the commencement of surveys and monitoring suggest a relatively small population that is substantially isolated. The Malleefowl are generally associated with deep sandy soil plains where they construct large mounds. In the Mt Jackson area, they tend to prefer shrubland of Tammar (*Allocasuarina campestris*) primarily on the lower slopes of the hills, although this is likely to be a confluence of the soil type favoured by both the Malleefowl and this vegetation (Bamford Consulting Ecologists 2005). The tops of hills at Mt Jackson are generally either too steep and/or rocky for mound construction.

The survey was undertaken by Eddy Cannella, Principal Zoologist with BIOSTAT Pty Ltd. Eddy Cannella has over 29 years of experience in terrestrial vertebrate fauna surveys in all areas of Western Australia. BIOSTAT has been involved in this survey since implementation and was also responsible for the redesign of the monitoring program.

2 METHODS

2.1 Scope of work

1. **Impact Assessment Monitoring (IAM)**: undertake survey of 67 Malleefowl Mounds in the Mt Jackson lease in accordance with the program established in 2013 (BIOSTAT Pty Ltd 2013)
2. **Year 3 Monitoring (Y3M)**: Survey all mounds designated for the 3-year cycle of monitoring for the National Database.

The major objectives to be completed as part of this survey are:

1. survey of 67 IAM mounds;
2. survey 105 Y3M mounds designated for the national Malleefowl Monitoring program;
3. measure active mounds in accordance with the agreed methodology; and
4. write a report of findings of the IAM survey and, where possible, make comparative assessments using available data.
5. determine the extent to which the data collected on this survey and on previous IAM surveys can be applied to the trigger criteria outlined in Section 8 of the Fauna Management Plan (Cliffs Natural Resources 2016).

2.2 Mound Selection

The survey was considered a continuation of the program established by BIOSTAT in 2013 and the same 67 mounds were surveyed in 2018 (Table 1). In addition, mounds surveyed annually as part of the Y3M program were included in this survey. There is an overlap of 24 mounds between the IAM survey and the Y3M survey. This will result in a total of 148 mounds to be surveyed during the 2018 event. However, the list of mounds provided by the NMRG for the Y3M included several other mounds with the total reaching 154 mounds. Three mounds could not be located during the survey (W17N134, 404 and 405) and two additional mounds (W17N139 and W17N174) were encountered and added to the list to be surveyed bringing the total mounds surveyed to 153.

Table 1 ***List of mounds to be surveyed.***

Mound Identifiers[1]								
W17N002	W17n065	W17n093	**W17n119**	W17n149	W17n183	223	**349**	404
W17N006	W17n066	W17n094	**W17n121**	**W17n150**	W17n184	W17n226	**353**	405
W17N007	W17n068	**W17n095**	W17n125	W17n155	W17n185	**244**	**354**	408
W17N024	W17n069	W17n096	**W17n126**	**W17n158**	**W17n186**	**247**	**356**	409
W17N035	W17n071	W17n097	W17n127	W17n159	W17n188	**263**	368	
W17N038	W17n072	W17n098	W17n128	W17n161	W17n189	**267**	**369**	
W17N045	W17n073	W17n099	**W17n129**	W17n166	W17n190	**288**	**375**	
W17N046	W17n074	**W17n100**	W17n131	W17n167	W17n191	**298**	**376**	
W17N047	W17n075	W17n101	**W17n132**	W17n168	W17n192	**301**	**378**	
W17n048	**W17n076**	**W17N102**	W17n134	W17n171	W17n193	**303**	**380**	
W17n055	W17n077	W17n104	W17n136	W17n172	W17n194	**304**	**384**	
W17n056	W17n078	W17n107	W17n137	W17N174	**W17N204**	**312**	**386**	
W17n057	W17n080	**W17n109**	W17N139	W17n175	**W17N207**	**317**	**390**	
W17n058	W17n081	**W17n110**	W17n140	W17n177	**W17N213**	**327**	**391**	
W17n059	W17n083	**W17n111**	W17n141	W17n178	**W17N216**	**328**	**395**	
W17n061	W17n085	**W17n112**	W17n142	W17n179	W17N217	**333**	**398**	
W17n062	W17n088	**W17n116**	W17n144	W17n180	220	**339**	**400**	
W17n063	W17n090	W17n117	W17n146	W17n181	221	**345**	402	
W17n064	W17n091	W17n118	W17n148	W17n182	222	**348**	**W17N403**	

A generalised standardised habitat survey method characterising habitat structure, developed by BIOSTAT, provides information on several variables relating to habitat structure. The variables include, numerical estimates of average tree height and litter cover percentage, as well as categorical measures such as landform type and disturbance level. Many of the variables have been adapted from Australian soil and landscape survey standards (National Committee on Soil and Terrain 2009). The measurements are an estimation based on a 20m radius of the survey point or the malleefowl mound, in this case. Observer bias is minimised by limiting the recording to one person. Habitat descriptions were recorded for all mounds encountered during the 2018 survey.

[1] Mound identifiers in bold are from the IAM survey.

2.3 Data Analysis

The data analysis was repeated from previous reports as a means of increasing the robustness of the investigations and the interpretation of results. The analysis of habitat characteristics were limited to its influence on mound activity as more comprehensive analyses were undertaken in the previous report (BIOSTAT Pty Ltd 2017).

The distance of mounds from the main mining operations was considered as an analogue to disturbance levels that may influence the likelihood of nesting activity by Malleefowl. A matrix of the linear distance of each surveyed mound to a central point, located at the approximate centre of the J1 disturbance area (GDA94/MGA94 Zone 50 708057mE, 6655034mN), was calculated using *Distance Matrix Analysis* tool in QGIS (Quantum GIS Development Team 2014).

Logit regression was undertaken testing distance as a predictor for mound activity using Generalised Linear Models (GLM) (Sokal & Rohlf 2011).

It was important to ensure that the analyses of this data set was selected and undertaken within the limitations of the survey methodology and the known biology of the species. It was critical that the complexity of analysis did not exceed the value of the available data, to avoid Type I and Type II errors (False Positive and False Negative errors respectively).

Habitat description environmental variable data collected from all IAM and Y3M was summarised. Comparisons were undertaken to investigate differences between environmental variables for active and inactive mounds.

All analyses were carried out in R (R Core Team 2016).

3 RESULTS

3.1 Weather Conditions

The survey was undertaken from 18-25 October 2018. There were no rain events during the survey although there were days of high humidity and cloud cover.

In previous years, daily rainfall and temperature data was obtained from the weather station located at the Windarling mine camp situated approximately 25 km north of Mt Jackson. However, this station had not been in operation for several months at the time of the survey due to the temporary cessation of mining. To provide some information on weather trends for the 2018 period, measurements were obtained from the Bureau of Meteorology Climate Data Online for sites close to Mt Jackson (http://www.bom.gov.au/climate/data/index.shtml). The two sites used were Southern Cross Airfield (temperature) and Koolyanobbing (rainfall), 100km and 58km south of Mt Jackson respectively. The difficulty in using data from distant sites is the applicability of results knowing there is likely to be a level of local variability.

Rainfall data from Windarling was also incorporated for comparison and it must be noted that 2015, 2016 and 2018 data sets were incomplete with one or more months of data not available in each year (Figure 2). Most of the rainfall is experienced during mid to late summer and is influenced by monsoonal weather patterns in the tropical zone to the north-west. Rainfall patterns at Windarling tend to be associated with some rain through most months of the year. There was a substantial drop in rainfall from 2014 to 2015, although there was an increase in rainfall in 2016 (Figure 3). There is a suggestion in the incomplete data set that, since 2014, Windarling has experienced more months without rain and generally a downward trend in rainfall. Due to the missing data from the 2018 Windarling rainfall measurements, it is difficult to determine if the trend is persisting.

Monthly temperatures data from the Southern Cross Airfield station, approximately 110 km to the south of Mt Jackson, were collected for the years 2010 onwards (Figure 2). Temperature ranges do vary in the 2013-2018 period. Average maximum monthly temperatures ranged from 37.3°C in January 2010, to 15.4°C in July 2016. Similar temperature variations in average minimum monthly temperatures with a top of 20°C in February 2015 and 1.4°C in July 2012. This differs from the available data for Windarling with average maximum monthly temperatures above 40°C during summer months, although average minimum monthly temperatures are relatively similar (BIOSTAT Pty Ltd 2018).

Seasonal temperature and rainfall conditions have been observed as playing a role in breeding activity of Malleefowl (Bode & Brennan 2011; Boyle & Hone 2012; Priddel & Wheeler 1990). The consensus among studies is that breeding is predicated on the rainfall experienced during the commencement of the breeding season (around September through to April). The Mt Jackson area experienced lower than average rainfall in 2015 which may have reduced breeding activity. A better than average rainfall in 2016 resulted in an increased level of activity during that year, but this was not observed in mound activity in 2017 and 2018.

Weather events are known to vary greatly locally. It can be the case that rainfall events may occur over the Mt Jackson range but not at Windarling or Koolyanobbing. This variability can be a critical factor in malleefowl activity and, especially their breeding success.

The unreliability of the weather measurements for the Mt Jackson area does make the analysis of factors affecting malleefowl activity more difficult. It is strongly recommended that a remote weather station be established at Mt Jackson to provide a better data source of local weather patterns.

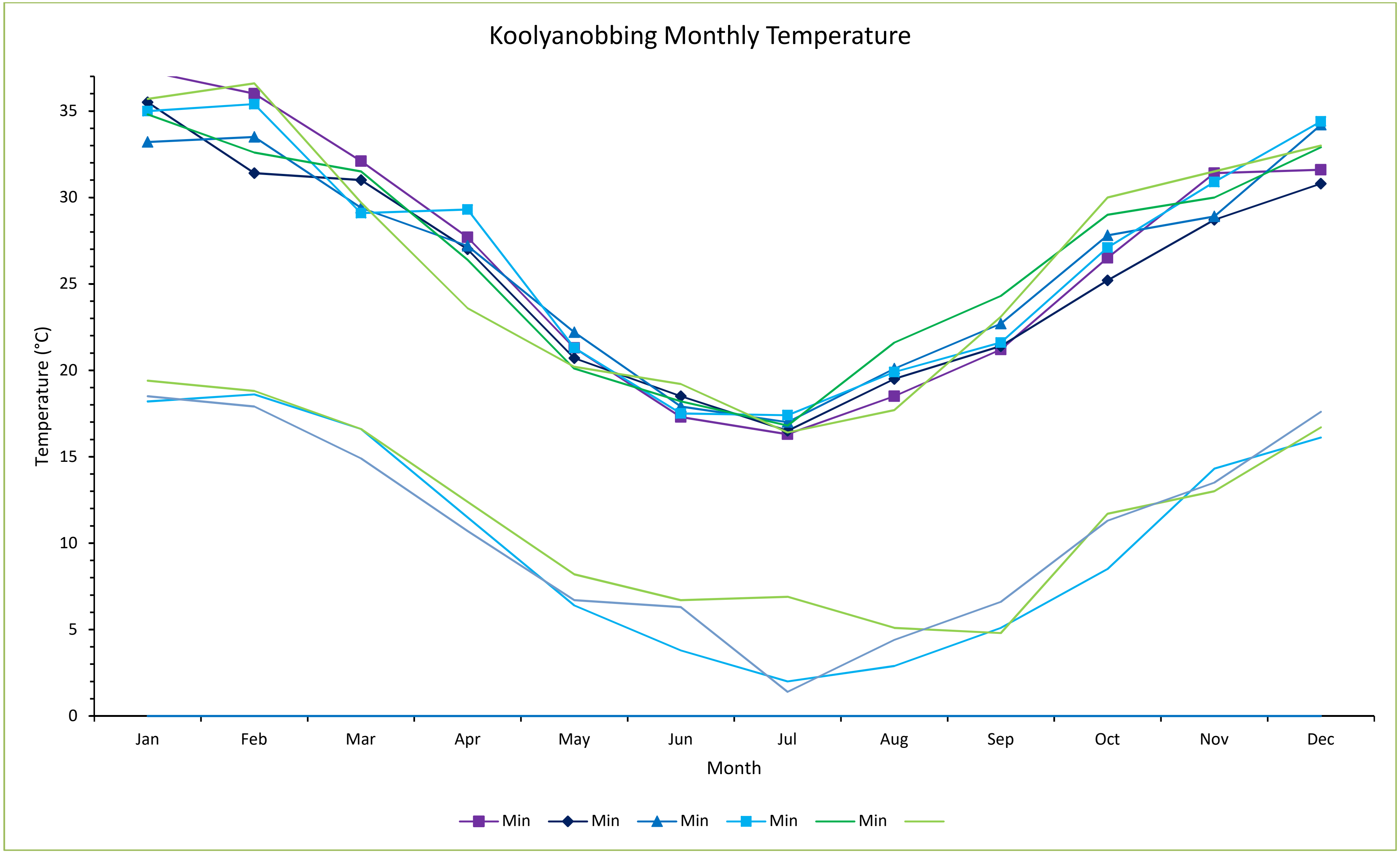

Figure 1 Average minimum and maximum monthly temperature for Southern Cross Airfield (2013-2018).

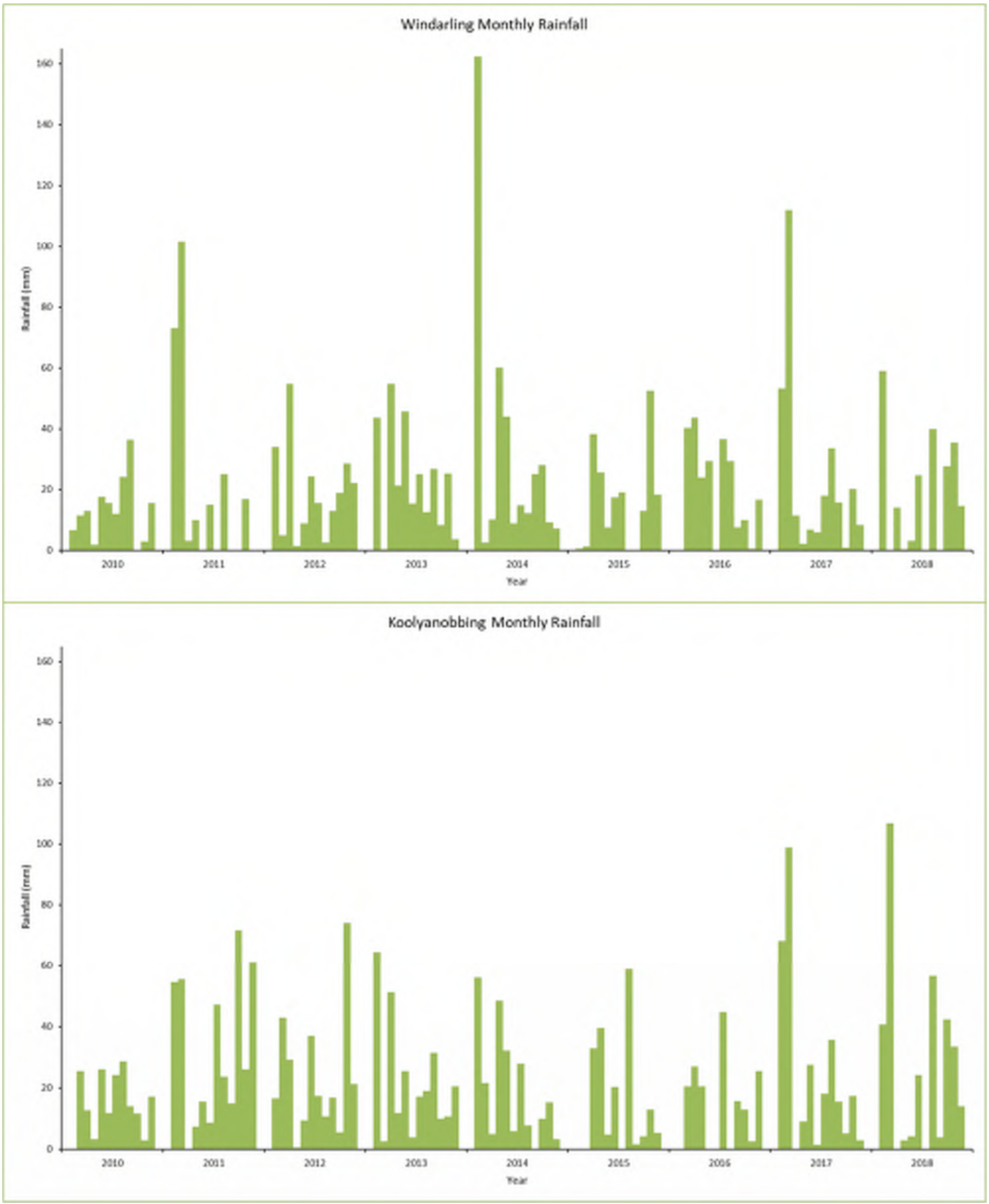

Figure 2 Monthly rainfall for Koolyanobbing and Windarling weather stations (2013-2018).

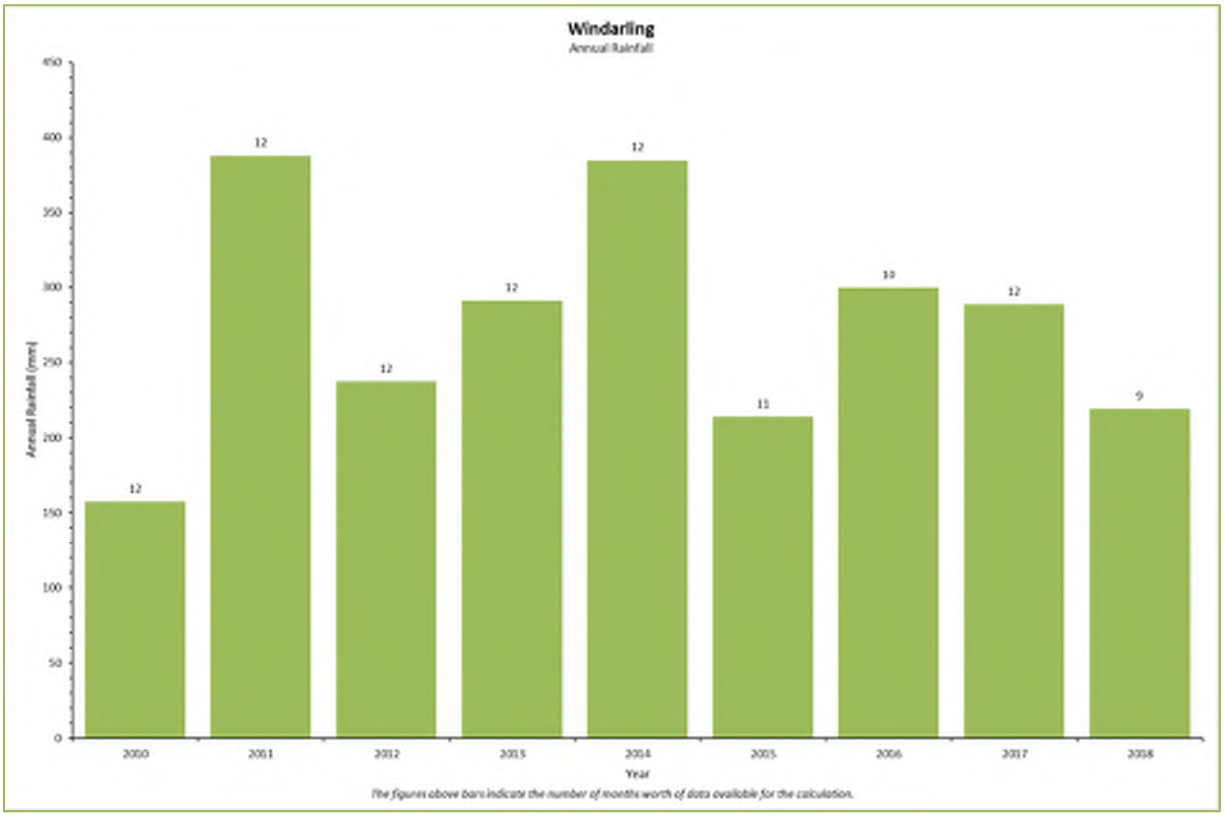

Figure 3 Annual rainfall at Windarling since 2010.

3.2 IAM Data Analysis

The data collected from this survey is tabulated in Appendix 1 and photographs of each of the surveyed mounds are provided in Appendix 2. A total of 16 active mounds were recorded in this survey (Figure 4[2]), one less than the previous year. The number of active mounds has declined since the high of 23 active mounds in 2014. However, two of the mounds were recorded as active for the first time since this monitoring program began (W17N247 and W17N354).

There is a small variation in the mounds that have been found to be active over the time of this program. Since the survey program began in 2013, 33 mounds have been recorded as active on one or more occasions (Figure 5). Eight of these mounds have been recorded as active over the 6 years of the program. Assessing mound usage patterns is complicated by the observations that some Malleefowl actively maintain more than the one mound but only lay in one of the tended mounds (Priddel & Wheeler 2003).

The estimate of population size assumes that each active mound belongs to one breeding pair with no overlap of territories. This is difficult to justify when some active mounds may occur relatively close to each other and may represent mounds prepared within the home range of the one breeding pair. However, by applying the same estimation method and understanding the possibility of inherent bias, the measures can be used for relative comparisons. The estimates of the breeding population range from 42 in 2013 to 32 recorded during this survey. If active mounds from the Y3M survey are included, the potential number of breeding pairs is 44 individuals.

The logit regression of mound activity and distance using 2018 survey data was not found to be significant (Table 2). Mound activity was correlated with distance in two years, 2013 and 2015. In all cases, there was a strongly significant intercept coefficients (p < 001) suggesting that the distance variable is not a strong determinant in the model.

Table 2 Regression lines derived from Logit analysis

Year	β_0 Intercept	Std. error β_0	β_1 Distance	Std. error β_1	$p(\beta_1)$
2013	-1.644	0.596	0.0734	0.0434	*
2014	-0.971	0.536	0.0284	0.0408	***N.S.***
2015	-2.555	0.745	0.1065	0.0508	*
2016	-1.735	0.619	0.0624	0.0448	***N.S.***
2017	-1.866	0.639	0.0665	0.0459	***N.S.***
2018	-1.712	0.629	0.0474	0.0459	***N.S.***

Significance: N.S. – Not Significant; $p < 0.05$ – *; $p < 0.0001$ – ***

[2] Please note the figure includes all IAM and Y3M mounds recorded as active.

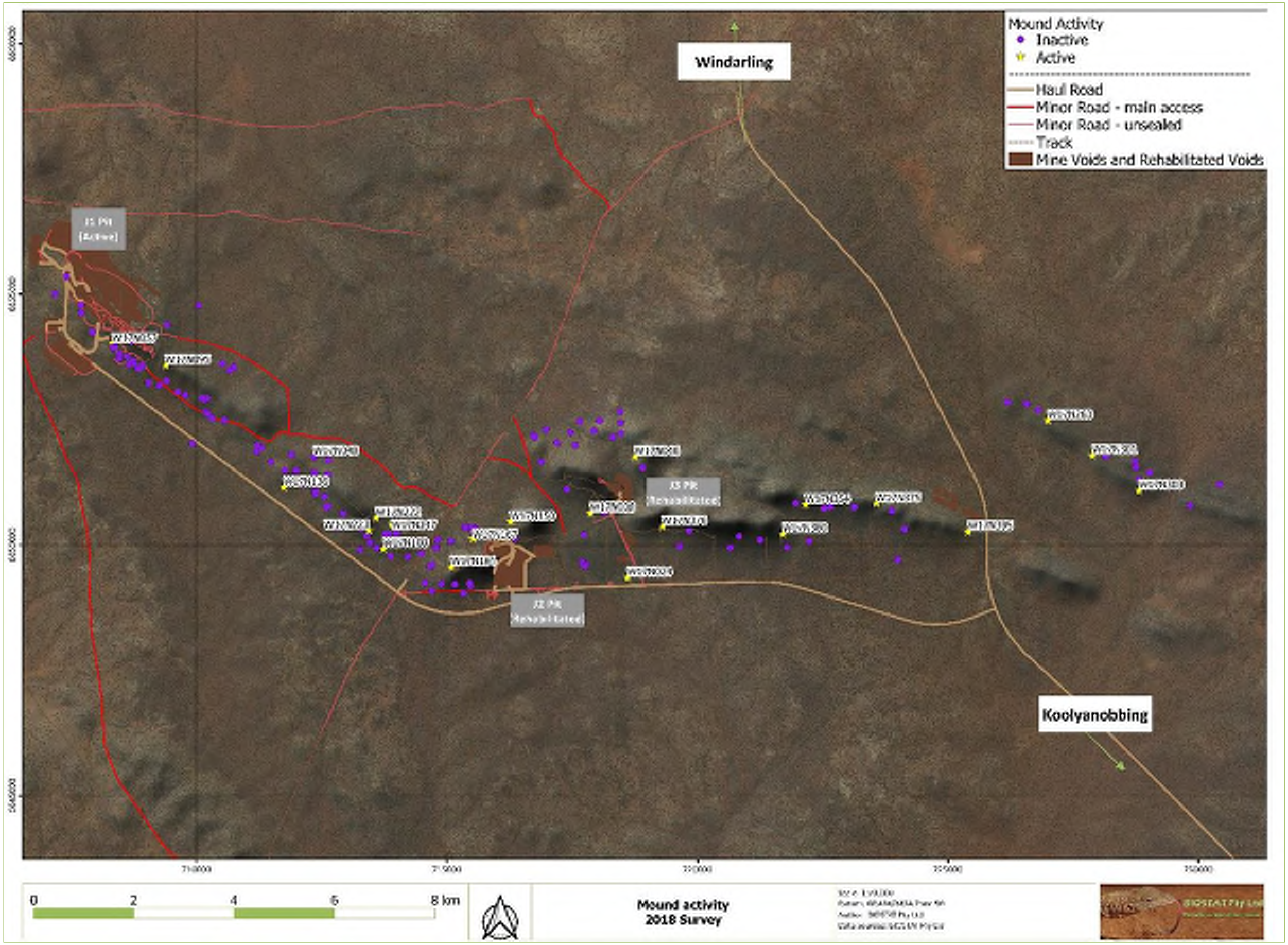

Figure 4 ***Distribution of Active and Inactive mounds in the project area.***

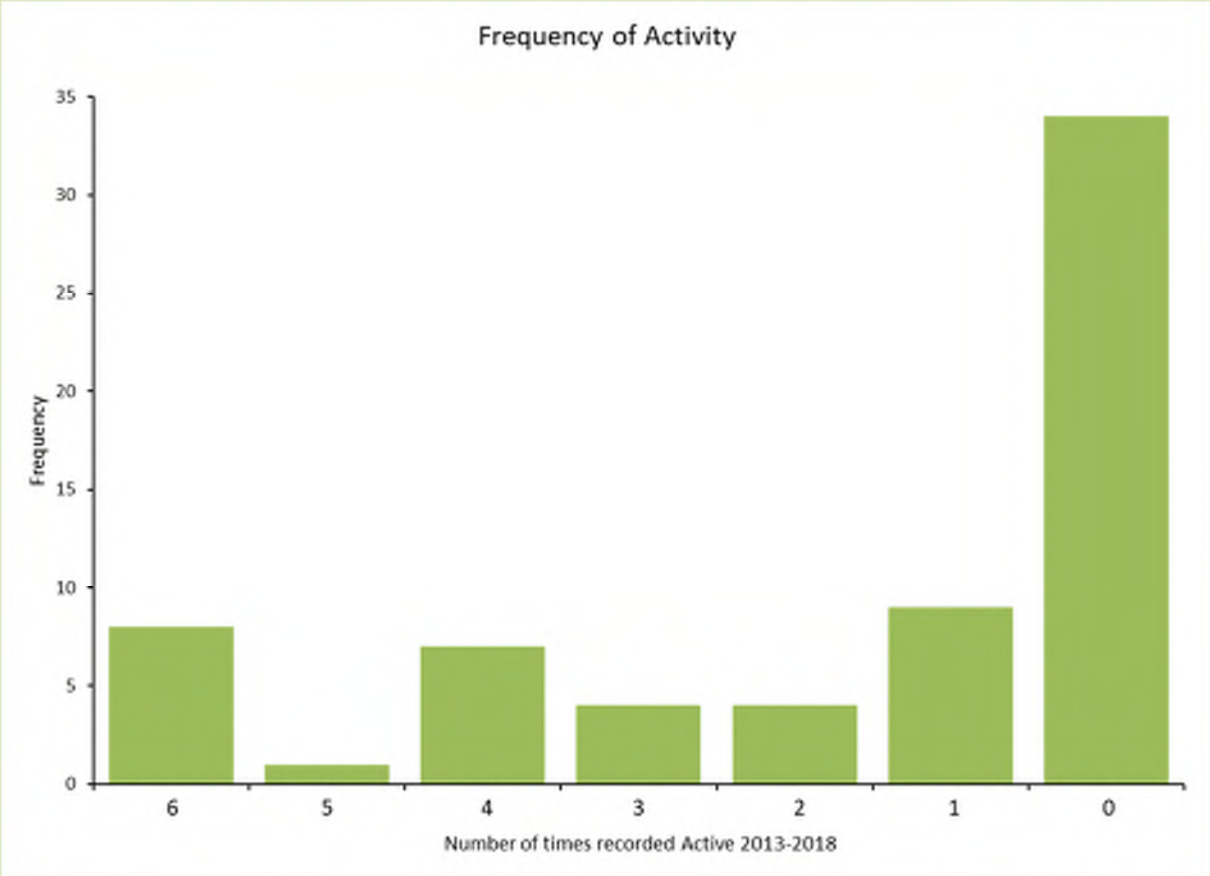

Figure 5 Frequency of activity for mounds surveyed since 2013.

3.3 Mound location characterisation

Summaries of environmental variables measured for all 153 collated for all mounds is provided in **Table 3**. Statistical comparisons between active and inactive mound sites did not result in significant difference in the environmental variables measured. However, although not statistically significant, there are some weak trends that have emerged from the data that will require further investigation.

A general description of mound habitat can be surmised from the available data such that most mounds are located:

1. In low disturbance areas;
2. In areas with little active erosion;
3. In variable shrubland with emergent trees;
4. In areas of variable litter cover but relatively dense lower stratum;
5. On slopes;
6. In relatively slightly rocky areas;
7. On silty clay soils with commonly associated with small surface fragments/pebbles.

This set of characteristics reflect the majority of habitat found at Mt Jackson. Differences between the locations of active mounds and inactive mounds are small with standard deviations overlapping. As with the general assessment of mound habitats, active mounds in comparison with inactive mounds, are characterised by:

1. Shorter average tree height but taller average shrub height;
2. Slightly greater levels of litter cover and lower stratum cover; and,
3. No other discernible difference in other environmental characteristics.

Table 3 Summary data for all environmental variables.

Variables	All Mounds (N=153)		Active Mounds (N=22)		Inactive Mounds (N=131)	
	mean	sd	mean	Sd	mean	sd
Average Tree Height (m)	7.59	2.57	7.05	2.42	7.68	2.6
Average Shrub Height (m)	1.99	0.61	2.19	0.57	1.96	0.62
Litter Cover (%)	15.52	8.98	16.82	5.24	15.31	9.46
Lower Stratum Cover (%)	45.73	15.78	49.59	16.08	45.08	15.7

Variables		All Mounds (N=153)	Active Mounds (N=22)	Inactive Mounds (N=131)
Disturbance	By animals only	144	22	122
	Limited clearing	6	0	6
	Highly disturbed	1	0	1
	No disturbance	2	0	2
Erosion	No erosion	138	21	117
	Active erosion	13	1	12
	Partly stabilised erosion	2	0	2
Hollows	Hollows Present	134	20	114
	Hollows Absent	19	2	17
Landform	Crest	18	1	17
	Flat	9	0	9
	Gully/gorge	3	2	1
	Hillock	3	1	2
	Lower slope	54	10	44
	Mid slope	25	6	19
	Open depression	1	0	1
	Ridge	2	0	2
	Simple slope	35	2	33
	Upper slope	3	0	3
Log Debris	Log debris present	150	22	128
	Log debris absent	3	0	3
Rocky Outcrop Type	Very rocky 20-30%	8	1	7
	Rocky 10-20-%	14	4	10
	Slightly rocky 2-10%	29	4	25
	Very slightly rocky <2%	65	7	58
	No rock outcrops	37	6	31
Surface Fragments	Many 20-50%	19	3	16
	Common 10-20%	87	9	78
	Few 2-10%	31	7	24
	Very few <2%	8	2	6
	No surface fragments	8	1	7
Surface Fragment Sizes	Stones 200-600mm	1	1	0
	Large pebbles 20-60mm	4	0	4
	Medium pebbles 6-20mm	45	3	42
	Small pebbles <6mm	103	18	85
Slope	Moderately inclined 10°	12	4	8
	Gently Inclined 3°	51	9	42
	Very gentle incline 1°	75	8	67
	Level	15	1	14
Soil Texture	Medium clay	3	1	2
	Light clay	2	0	2
	Deep Sands	2	0	2
	Silty clay loam	143	20	123
	Clay loam, Sandy	3	1	2

3.4 Malleefowl observations

The malleefowl is a cryptic species not often observed in the field. However, during breeding they are sometimes seen near active mounds. During the survey 8 malleefowl[3] individuals were observed (Table 4). Three of these individuals were observed attending active mounds. Two others were recorded near active mounds (W17N222 and W17N303).

Table 4 Observations of malleefowl individuals.

Line or Sighting ID	Remarks
W17N095	Observed attending mound
W17N136	Observed attending mound
MF1	Disturbed it while resting under *Santalum* sp. shrub
MF2	This was sighted only about 100m from MF1 and could be the same individual
W17N222	Heard and seen on approaching active mound W17N222 but not observed attending to that mound
MF3	Disturbed from under shrub while walking to W17N140
W17N354	Observed attending mound
W17N303	Resting under *Allocasuarina campestris* next to active mound

3.5 Compliance with Management Criteria

The Yilgarn Operations Fauna Management Plan (Yilgarn Iron Pty Ltd 2019) establishes the criteria that are used to trigger actions to manage and mitigate impacts on malleefowl. The trigger of these criteria are dependent on indirect measures of activity, such as mound activity monitoring. The criteria are:

"For Leipoa ocellata (Malleefowl), reporting and contingency actions will be triggered if any of the following occur:

- *Annual monitoring indicates a decline in Malleefowl breeding activity (as measured by the number of active core mounds) of >35% between consecutive years, and a decline of similar magnitude is not reflected in the animal sightings register.*
- *Annual monitoring indicates a consistent pattern of decline in Malleefowl breeding activity over a timeframe of three years or more and a similar decline is not reflected in the sightings register.*
- *Annual monitoring indicates a spatial trend of declining breeding activity that may be related to proximity to mining operations."*

The only consistently collected data is derived from the IAM survey. This survey was designed specifically to deal with the third criteria. Even with a smaller subset of mounds surveyed for the IAM program, the consistency brought by annual surveying of the same mounds does allow for the assessment of trends or patterns in activity.

The data collected for IAM does not trigger the first of these criteria (Figure 6) although there was a large drop in mound activity from 2014 to 2015 of 31.8%. This was followed by an increase in 2016 with greater levels of mound activity. There has been a small annual decrease in mound activity within the IAM since 2016. However, it is difficult to determine the causal factors as this drop could be associated with seasonal conditions (e.g., rainfall and temperatures), changes in mound usage patterns (i.e., use of mounds that are not surveyed) or even impacts from such management actions as introduced predator control.

Sightings register data collates opportunistic sightings of animals by mine personnel in their day to day activities. The register cannot be considered as wholly representative of malleefowl activity within the

[3] One individual was observed soon after disturbing another that flew in the general direction of the second encounter.

area as the quality of the data is highly variable. For example, the register data fails to show the increase in activity recorded in the IAM mound surveys for 2016. The quality of data in the register is dependent on the identification skills of all personnel, their diligence in reporting the information, and the training provided to encourage personnel to participate in the register. The inconsistencies in the quality of the data present a problem in the inclusion of this information in criteria for management of the species. It is strongly recommended that the observation register be maintained for anecdotal data collection rather than a critical component of criteria determination.

With considerations to the limitation of the register data, the malleefowl sightings for the 2013-2018 period does parallel a downward trend in mound activity (Figure 7). What the data fails to show is the increase in activity noticed in the IAM mound surveys for 2016 which was substantial relative to other years.

The drop in both mound activity, determined from the surveys, and observation data, from the register, has only occurred over a two successive year period (2017 and 2018) and do not, at this time, trigger the second criteria.

It is unclear as to the exact factors that underpin this downward trend. Malleefowl are a long-lived species and care for multiple mounds over their lifetime. It may be a case that breeding mounds are not within the subset being surveyed for the IAM program.

The IAM survey was specifically designed to test the last criteria. The design of the survey considered the level of activity as a measure of distance from the main point of mining operations, J1 pit, on the western end of the Mt Jackson range. The data consistently shows no relationship between distance from J1 pit and mound activity. This is in part due to the breeding behaviour of this species. Malleefowl males, the primary creator of mounds, have:

- relatively large territories;
- are mobile;
- long lived;
- generally monogamous; and,
- maintain more than one mound at any one time (although only one mound is generally used for nesting).

Although this cannot be effectively investigated with the available data, it is speculated that any long-lasting impacts on those individuals at any of the mining pits occurred at the time of the clearing and operations of those pits. This would have resulted in the loss of territory for individuals with the potential outcomes that the individuals:

- moved to a new area and established a new territory within Mt Jackson;
- moved out of the Mt Jackson area entirely; or
- did not survive the loss of territory.

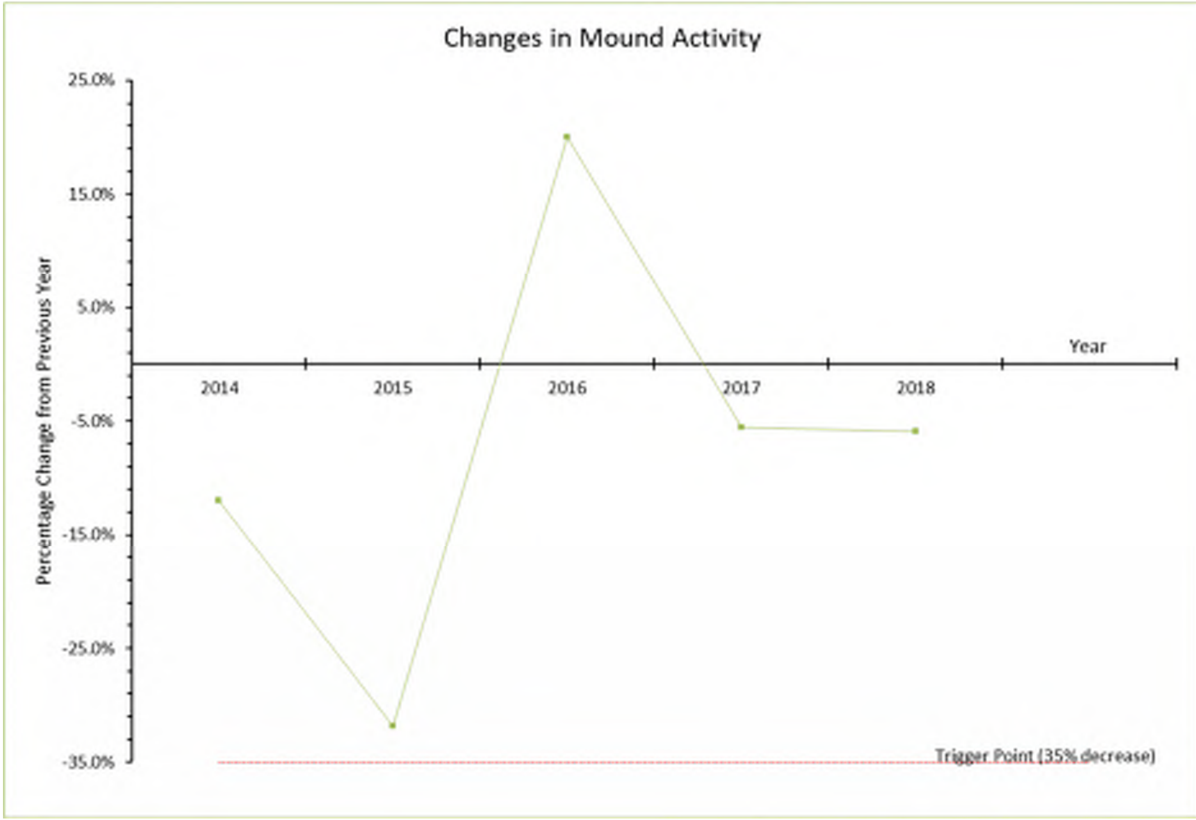

Figure 6 Changes in mound activity expressed as percentages.

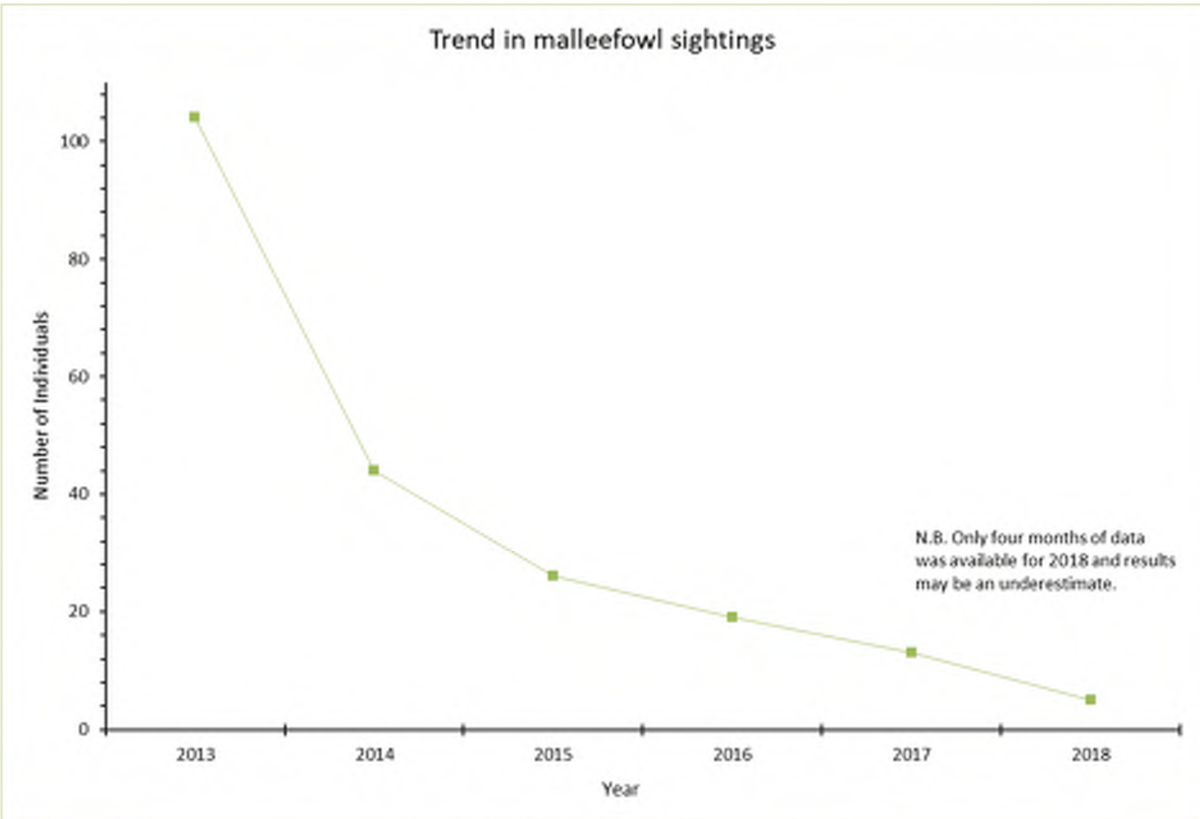

Figure 7 Changes in malleefowl sightings at the mine operations

3.6 Adaptive Management Experiment

The National Malleefowl Recovery Group (NMRG) provides a National approach to the conservation and management of the malleefowl. In its activities and through partnerships with various stakeholders, it has established numerous monitoring sites across Australia of which Mt Jackson is included. To provide greater applicability of their research, the NMRG is establishing an Adaptive Management Experiment (Hauser et al. 2019; Walsh et al. 2012), AME, that:

- Standardises monitoring at each of its sites thus allowing comparisons on a local, regional and national basis;
- Incorporates predator control as one of the focus points; and
- Attempts to provide effective and expedient data from each of its sites to allow for adaptive management of these populations.

The opportunity to engage in AME will allow for a more focused approach to malleefowl monitoring in the Mt Jackson area that should provide a greater level of certainty from the collected information. Furthermore, the standardisation of methods can provide a greater understanding of the population dynamics of the Mt Jackson malleefowl population from direct comparisons of annual data collected from the same mounds. The incorporation of predator monitoring also provides some useful information on the impacts of predators on malleefowl and the effectiveness of predator control measures. The predator monitoring is a component of the AME and consists of the establishment of regular grids of up to 10 cameras placed in the project area for continuous monitoring.

A preliminary attempt to design the mound monitoring program was made using data obtained from MRL. The exercise involved establishing a selection-criteria for mounds to be monitored. Once selected, the data set will form the basis of the monitoring program for the foreseeable future.

An initial data set was created of mounds that were:

- Not regarded as extinct;
- Not on the 5-year monitoring plan (i.e., old mounds unlikely to be used again);
- Mounds that could not be located during previous surveys (error in coordinates); and
- Mounds that on inspection were regarded as natural features (e.g., geological features, anthropogenic features).

The initial pass of the mounds present in the Mt Jackson area resulted in 177 mounds available for monitoring. From past knowledge of the logistical limitations of surveying in the Mt Jackson area it is recommended that 100 mounds be selected for monitoring on an annual basis. This allows one person or a team of two people to safely negotiate the survey in 6-7 days.

The IAM survey collected annual data for 67 mound locations. After applying the initial criteria, the number of IAM mounds was reduced to 43. These were included as the core to the list of mounds for monitoring.

A further 33 mounds that met the initial criteria were surveyed in 2018 and were included into the data set for continuity.

Another 24 mounds were chosen for inclusion into the AME data set. In part, these were chosen based on ease of access (access to most mounds is via trekking through difficult country).

The final data set consisted of 100 mounds (Appendix 3) of which:

- 43 mounds have had data collected in consecutive years from 2013 to 2018;
- 33 mounds with data collected in 2018 and 2015;
- 12 mounds with data collected in 2017 and 2014; and
- 12 mounds with data collected in 2016 and 2013.

The large area over which the mounds are distributed would benefit from the establishment of at least the maximum number of cameras intended for predator impact assessment.

4 DISCUSSION AND CONCLUSIONS

The 2018 survey confirmed the findings of previous surveys. The data indicated there is no significant relationship between mound activity and the distance from the main sources of mine activity and, overall the number of active mounds is relatively stable with only small fluctuations in estimated population within the sample group.

A previous report on the survey results (BIOSTAT Pty Ltd 2017) analysed environmental factors associated with Malleefowl mound activity. It relied on the information collected from the 67 mounds selected for the IAM survey. The 2018 event provided the opportunity to survey a total of 153 mounds and collect environmental factor data on the additional mound locations.

Malleefowl construct their mounds in areas they consider suitable. There are potentially many factors that could influence the location of the mound. An understanding of some of these reasons can be achieved through the measurement of environmental factors at the site of existing mounds.

There are several considerations in assessing the interaction of mound location through the chosen variables measured during the survey:

1. All mounds were constructed because environmental factors were suitable at the time. This is of critical importance when assessing old and extinct mounds.
2. Not all mounds are used for laying. Some mounds may have been begun but abandoned early in the construction process. A mounds history cannot be assumed prior to the time monitoring commenced.
3. Standardised habitat survey metrics have been chosen to describe broader habitats rather than capture specific microhabitat variables associated with malleefowl mound locations. A modification of the habitat survey including mound location specific variables may be required to determine environmental factors.

The original analysis of the 2016 data suggested there may be some weak relationship between shrub cover and mound activity. However, the analysis of the larger data set from 2018 Analysis of the larger data from 2018 resulted in no significant relationships between factors and mound activity.

Mound activity has fluctuated over the 6 years of the IAM program with drops in activity recorded in most years, the exception being a rise from 2015 to 2016. Breeding activity success in malleefowl is associated with rainfall frequency among other factors. This is especially so if rainfall events occur frequently enough to provide foraging resources to supply the nutrition allowing females to gain the necessary condition for breeding.

There is a need for constant monitoring of the malleefowl population due to the influence of numerous factors influencing the population. Information gained from the monitoring can inform the adaptive management of the population (Hauser et al. 2019). Factors such as the reintroduction of stock, feral predator management and climatic variability and their effect on the population are significant in modifying management objectives and mitigation responses.

The IAM program has highlighted that further work is needed to understand dynamics of the population in the Mt Jackson area. The establishment of the AME provides the impetus to redesign the monitoring program to allow for a more focused investigation that will feed directly into the management of the species. The inclusion of additional mound data as part of the IAM survey also highlighted the value of a larger sample size in the interpretation of malleefowl population dynamics.

The major constraint in the research of malleefowl is their longevity. It is necessary to consider any research into this species will always be mid- and long-term propositions. The continued annual long-term monitoring of mound activity via AME is more likely to determine needs in the management of this species. The value of AME is that with annual data collected from the same mounds, it is likely that any changes may be detected earlier than the current 3-year monitoring cycle system. Any results can be considered and integrated into management of the malleefowl at Mt Jackson.

Assessment of the survey data against the criteria, listed in the Fauna Management Plan, will trigger any need for further management actions. It was found that there has been a notable decline in mound activity, the rate of decline has fallen since 2014 with one positive spike in activity in 2016. This decline has not been of the magnitude that would have resulted in the triggering of the first criteria (i.e., >35% drop in activity in consecutive years).

The use of the sightings register as a source of robust information on malleefowl activity is questioned and is not recommended as a viable measure. The establishment of more robust surveying methods, such as permanent camera stations, would be preferable. It is suggested that the second criteria be reviewed and possibly removed from the list.

The final criteria assessing potential mine impact was specifically the focus of the IAM surveys. As already indicated earlier, there has not been any suggestion that proximity to mine operations has impacted mound activity.

The analysis of the data in relation of the management action criteria in Yilgarn Fauna Management Plan (Cliffs Natural Resources 2016) did raise issues in terms of relevance and efficacy. One of the least credible data sources utilised in determining the trigger criteria is the sightings register. This should be removed as a requirement and the trigger criteria should be based on more robust data. The determination of population dynamics and other impacts is most likely to be facilitated from the AME style of monitoring, i.e., regular, standardised and long-term.

As a component of the management program, the IAM monitoring has reached its conclusion with results indicating no measurable impact of mine operations on mound activity. However, the establishment of the AME where the same mounds are monitored on an annual basis will continue to provide data suitable for the analysis of impacts on the malleefowl population.

The difficulty in interpreting the weather information for the Mt Jackson area is also of concern. The high level of variability in weather patterns between Mt Jackson, Windarling, Koolyanobbing and areas further afield make it very difficult to assess weather impacts on the malleefowl populations. Therefore, it is recommended that an automated remote weather station be established at Mt Jackson to provide continuous data on weather events throughout the year. This station can be established at either J2 or J3 and be regularly maintained.

Irrespective of the recommendations made here, the priority of the monitoring program must be to provide information that can be integrated into the adaptive management of the Mt Jackson malleefowl population.

5 ACKNOWLEDGEMENTS

I would like to thank the staff of the Environment team at Mineral Resources Ltd for their assistance in this survey.

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Appendix 1. IAM Mound Data Survey Results 2018

	Year of Survey						
Nest ID	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Distance (m)**
W17N002							10820.58
W17N024	Y	Y	Y	Y	Y	Y	12109.89
W17N035	Y	Y					11001.55
W17N038	Y	Y	Y	Y	Y	Y	10755.81
W17N045	Y	Y					10130.44
W17N046	Y	Y		Y		Y	11189.43
W17N047	Y	Y	Y	Y	Y		11398.15
W17N048		Y	Y	Y		Y	5392.61
W17N055							427.5074
W17N062							532.9771
W17N063							1173.711
W17N064							1392.469
W17N076							1703.138
W17N095	Y	Y			Y	Y	1970.875
W17N100	Y				Y	Y	7643.019
W17N102							7364.7
W17N109	Y	Y		Y			6258.736
W17N110							6240.522
W17N111							6069.843
W17N112	Y	Y	Y		Y		6570.023
W17N116							7042.886
W17N119							5020.345
W17N121					Y		5130.547
W17N126							5595.717
W17N129				Y			5834.537
W17N132							7641.842
W17N150	Y	Y	Y	Y	Y	Y	9404.575
W17N158							8797.32
W17N186							9448.773
W17N204		Y					1506.894
W17N207							1999.526
W17N213							2838.472
W17N216							3071.994
W17N244							5668.132
W17N247						Y	7461.454
W17N263	Y	Y	Y	Y	Y	Y	19113.31
W17N267							20361.68
W17N288	Y		Y	Y	Y		20951.54
W17N298							18888.96
W17N301	Y	Y	Y	Y	Y	Y	20099.39
W17N303	Y	Y	Y	Y	Y	Y	21135.86
W17N304							21277.25
W17N312	Y						22190.89
W17N317							18265.15
W17N327	Y	Y					21091.27
W17N328							20990.21
W17N333							22696.71
W17N339							16815.18
W17N345							12699.35
W17N348	Y						13584.75
W17N349		Y		Y	Y		13671.86
W17N353							15016.21
W17N354						Y	14724.6
W17N356		Y					15095.99

	Year of Survey						
Nest ID	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Distance (m)**
W17N369		Y	Y	Y	Y		14640.94
W17N375	Y	Y	Y	Y	Y	Y	16079.65
W17N376		Y	Y	Y		Y	12177.56
W17N378							12639.89
W17N380					Y	Y	14474.72
W17N384							15670
W17N386							16409.63
W17N390							15216.03
W17N391			Y				16761.33
W17N395	Y	Y	Y	Y	Y	Y	17996.39
W17N398							14530.19
W17N400							11133.91
W17N403	Y	Y		Y			5300.163
Active Nests	**21**	**23**	**15**	**18**	**17**	**16**	

Appendix 2. Photographs of mounds 2018 (IAM and Y3M)


W17N002


W17N006


W17N007


W17N024


W17N035


W17N038

W17N045


W17N046


W17N047


W17N048


W17N055


W17N056

W17N057

W17N058

W17N059

W17N061

W17N062

W17N063

W17N064

W17N065

W17N066

W17N068

W17N069

W17N071

W17N072

W17N073

W17N074

W17N075

W17N076

W17N077

W17N078

W17N080

W17N081

W17N083

W17N085

W17N088

W17N090

W17N091

W17N093

W17N094

W17N095

W17N096

W17N097

W17N098

W17N099

W17N100

W17N101

W17N102

W17N104

W17N107

W17N109

W17N110

W17N111

W17N112

W17N116

W17N117

W17N118

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W17N172

W17N174

W17N175

W17N177

W17N178

W17N179

W17N180

W17N181

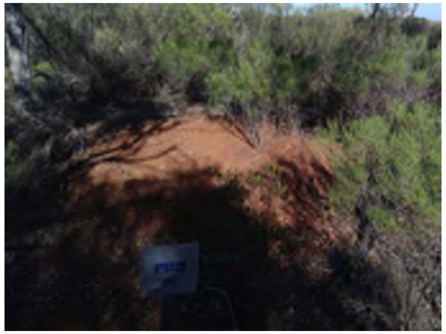
W17N182

W17N183

W17N184

W17N185

W17N186



W17N188

W17N189

W17N190

W17N191

W17N192

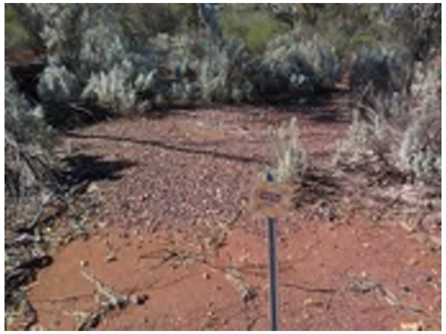
W17N193

W17N194

W17N204

W17N207

W17N213



W17N216

W17N217

W17N220

W17N221

W17N222

W17N223

W17N226

W17N244

W17N247

W17N263

W17N267

W17N288

W17N298

W17N301

W17N303

W17N304

W17N312

W17N317

W17N327

W17N328

W17N333

W17N339

W17N345

W17N348

W17N349

W17N353

W17N354

W17N356

W17N368

W17N369

W17N375

W17N376

W17N378

W17N380

W17N384

W17N386

W17N390

W17N391

W17N395

W17N398

W17N400

W17N402

W17N403

W17N408

W17N409

Appendix 3. Suggested mounds for AME Monitoring

National ID	Site code	First recorded	Easting	Northing	Datum
w17n002	2	2004	717599	6650054	WGS84
w17n006	6	2004	717704	6649649	WGS84
w17n016	16	2004	718103	6649611	WGS84
w17n019	19	2004	718288	6649867	WGS84
w17n020	20	2004	718310	6649793	WGS84
w17n023	23	2004	718433	6649611	WGS84
w17n024	24	2004	718752	6649477	WGS84
w17n030	30	2004	717759	6650223	WGS84
w17n031	31	2004	718208	6650269	WGS84
w17n032	32	2004	718166	6650427	WGS84
w17n035	35	2004	718007	6650501	WGS84
w17n037	37	2004	717840	6650532	WGS84
w17n038	38	2004	717730	6650482	WGS84
w17n042	42	2004	717866	6650168	WGS84
w17n045	45	2004	717396	6651108	WGS84
w17n046	46	2004	718757	6651760	WGS84
w17n047	47	2004	718907	6651541	WGS84
w17n048	48	2005	712205	6651615	WGS84
w17n056	56	2005	707781	6654104	WGS84
w17n057	57	2005	708191	6653865	WGS84
w17n058	58	2005	708317	6653570	WGS84
w17n062	62	2005	707562	6654486	WGS84
w17n069	69	2005	709406	6653279	WGS84
w17n072	72	2005	709050	6653236	WGS84
w17n073	73	2005	709782	6652990	WGS84
w17n078	78	2005	708195	6653789	WGS84
w17n080	80	2005	710316	6652536	WGS84
w17n081	81	2005	710559	6652494	WGS84
w17n083	83	2005	710190	6652663	WGS84
w17n088	88	2005	711302	6651937	WGS84
w17n095	95	2005	709251	6653434	WGS84
w17n096	96	2005	710222	6652621	WGS84
w17n097	97	2006	714218	6649761	WGS84
w17n098	98	2006	713878	6649768	WGS84
w17n099	99	2006	713843	6650220	WGS84
w17n100	100	2006	713739	6649922	WGS84
w17n101	101	2006	713601	6649947	WGS84
w17n102	102	2006	713470	6650040	WGS84
w17n109	109	2006	712634	6650765	WGS84
w17n111	111	2006	712563	6650967	WGS84
w17n112	112	2006	712929	6650626	WGS84
w17n116	116	2006	713156	6650178	WGS84
w17n121	121	2006	711625	6651339	WGS84
w17n126	126	2006	712211	6651297	WGS84
w17n129	129	2006	712484	6651254	WGS84
w17n131	131	2006	714163	6650007	WGS84
w17n136	136	2006	711750	6651145	WGS84
w17n148	148	2007	715510	6650290	WGS84
w17n149	149	2007	715526	6650313	WGS84
w17n150	150	2007	716274	6650459	WGS84
w17n159	159	2007	715566	6650330	WGS84
w17n166	166	2007	716361	6650126	WGS84
w17n167	167	2007	715526	6650119	WGS84

National ID	Site code	First recorded	Easting	Northing	Datum
w17n184	184	2007	715090	6649558	WGS84
w17n185	185	2007	714787	6649946	WGS84
w17n186	186	2007	716885	6651665	WGS84
w17n189	189	2007	715338	6649031	WGS84
w17n194	194	2007	714710	6649606	WGS84
w17n204	204	2008	709280	6654243	WGS84
	221	2009	710154	6652904	WGS84
	222	2009	713591	6650538	WGS84
	223	2009	713448	6650284	WGS84
w17n226	230	2006	714489	6649827	WGS84
	247	2009	713906	6650401	WGS84
	263	2010	727000	6652486	WGS84
	288	2010	728737	6651670	WGS84
	301	2010	727893	6651789	WGS84
	303	2010	728820	6651080	WGS84
	312	2010	729837	6650782	WGS84
	327	2010	728817	6651309	WGS84
	330	2010	729774	6650940	WGS84
	331	2010	730272	6650580	WGS84
	332	2010	730322	6650725	WGS84
	337	2011	722539	6650556	WGS84
	349	2011	720694	6650021	WGS84
	353	2011	722090	6649925	WGS84
	354	2011	722019	6650650	WGS84
	356	2011	722386	6650581	WGS84
	366	2011	720955	6649757	WGS84
	367	2011	721278	6649784	WGS84
	368	2011	721251	6650099	WGS84
	369	2011	721648	6649805	WGS84
	373	2011	722744	6650755	WGS84
	375	2011	723435	6650674	WGS84
	376	2011	719164	6650217	WGS84
	377	2011	719490	6650249	WGS84
	379	2011	721167	6649683	WGS84
	380	2011	721567	6650070	WGS84
	381	2011	721838	6650066	WGS84
	383	2011	722826	6650748	WGS84
	389	2011	721874	6650714	WGS84
	390	2011	722520	6650611	WGS84
	391	2011	723999	6650163	WGS84
	392	2011	724392	6648481	WGS84
	395	2011	725410	6650264	WGS84
	396	2011	725680	6650506	WGS84
	397	2011	724182	6649947	WGS84
W17n403	403	2012	711971	6651489	WGS84
	408	2014	707860	6653814	WGS84
	409	2014	726434	6652682	WGS84

Attachment 17 – Restoration Research Final Report: *Ricinocarpos brevis* 2013-2018

BOTANIC GARDENS & PARKS AUTHORITY

KINGS PARK SCIENCE

ABN 30 706 225 320

Restoration Research Final Report: *Ricinocarpos brevis* (Euphorbiaceae)

2013 - 2018

Produced for:

Cliffs Asia Pacific Iron Ore Pty Ltd.

KINGS PARK SCIENCE

1 Kattidj Close, Kings Park

Western Australia 6005

www.bgpa.wa.gov.au

EMAIL: scienceadmin@dbca.wa.gov.au

Telephone: +61 8 9480 3614

Facsimile: +61 8 9322 3641

GOVERNMENT OF WESTERN AUSTRALIA

BOTANIC GARDENS & PARKS AUTHORITY

KINGS PARK SCIENCE

ABN 30 706 225 320

Dr Carole Elliott
Research Scientist, Botanic Gardens and Parks Authority (DBCA), West Perth, WA, 6005.
University of Western Australia, Crawley, WA, 6009
Email: Carole.Elliott@dbca.wa.gov.au

Dr Shane Turner
Research Scientist, Botanic Gardens and Parks Authority (DBCA), West Perth, WA, 6005.
University of Western Australia, Crawley, WA, 6009
Email: Shane.Turner@dbca.wa.gov.au

Dr Ben Miller
Director of Science, Botanic Gardens and Parks Authority, West Perth, WA, 6005.
Department of Biodiversity, Conservation and Attractions (DBCA)
Email: Ben.Miller@dbca.wa.gov.au

KINGS PARK SCIENCE
1 Kattidj Close, Kings Park
Western Australia 6005
www.bgpa.wa.gov.au

EMAIL: scienceadmin@dbca.wa.gov.au
Telephone: +61 8 9480 3614
Facsimile: +61 8 9322 3641

Preface (Scope and Limitation)

This final report is a culmination of findings from a five-year research program agreed by the Botanic Gardens and Parks Authority (BGPA) and Cliffs Asia Pacific Iron Ore (Cliffs). The program was undertaken from March 2013 to March 2018 at Cliffs' Windarling tenement (Mining Lease M77/1000) in the Goldfields region of Western Australia. The program was divided into three research themes: **1)** Interactions of *Ricinocarpos brevis* with its environment; **2)** Optimisation of the restoration environment for *R. brevis*; and **3)** Optimisation of *R. brevis* plant establishment in restoration. Within each theme, there were a number of complimentary research modules that were designed to address the overall research goals.

A Variation to Service Agreement, signed June 2016, outlined the transfer of several research modules relating to elements of the program from BGPA to Cliffs and the Australian Research Council (ARC) – funded Industrial Transformation Training Centre (ITTC), administered by Curtin University and based at BGPA and other partner organisations.

This document reports on the findings and recommendations generated by research conducted by BGPA during March 2013 and March 2018. This work was principally carried out by Dr Carole Elliott and Dr Shane Turner, unless as stated in the Acknowledgements. The structure of the research program (Table 1) pertains to the original research outline agreed upon (March 2013) and specifically stipulates what research items BGPA has reported on, as per the Variation to Services Agreement (June 2016) in this final report.

The completion of the research program would not have occurred without the dedicated work of staff, students and volunteers. We would like to thank all involved from:

- Cliffs Asia Pacific Iron Ore
- Botanic Gardens and Parks Authority
- The University of Western Australia
- Murdoch University
- Australian Nuclear Science and Technology Organisation

Cliffs Asia Pacific Iron Ore were instrumental in the facilitation and operation of this research program. Specifically, Cliffs staff:

- consolidated and supplied as requested the background information;
- assisted with the project scope and design, including translocation proposals, site selection and ongoing maintenance;
- facilitated access to all sites;
- provided transport, accommodation and meals as needed;
- provided resources and assistance on site; and
- maintained research infrastructure and pest control.

Executive Summary

- *Ricinocarpos brevis* is a threatened shrub restricted to just three populations north of Southern Cross that has been significantly affected by mine related activities.
- As part of an offsets package, Cliffs Asia Pacific Iron Ore supported a five-year integrated research program focussing on this species.
- Significant developments in the restoration of sustainable population of *Ricinocarpos brevis* have been achieved through this five year research program:
  - Appropriate technologies have been defined for the restoration of populations.
  - Protocols for the *in situ* (field based) establishment of plants have been identified.
  - Important ecological processes, such as seed dispersal, were observed, but only operating at a 'moderate' level, in restoration areas (waste rock landforms)
- Development of abiotic and biotic measures to monitor translocation success and maturation against the natural population of plants as a benchmark.
- Completion of a Restoration Manual on *Ricinocarpos brevis* for restoration practitioners and future translocations.
- Key findings from the research program
  - *Ricinocarpos brevis* has limited natural recruitment; it is outcrossed and the rate of floral development is sensitive to temperature; it requires pollination via a generalist community of insect floral visitors; has a variable capacity for reproduction (floral and seed production) that is highly sensitive to seasonal conditions; and its seed is dispersed by gravity or ants.
  - Soils in natural populations have variable but overall similar texture to those of translocation sites on waste rock landforms; variable chemistry; variable but similar hydrological properties; and aspect of site affected soil temperature and soil moisture dynamics.
  - Three site amendments (caging, shade, irrigation) improved the survival and growth of seedlings and tubestock, and one (fertiliser) had a mixed response.
  - Topsoil is a poor source of seed for translocation but is a critical medium for translocation activities.
  - Cool temperatures, burial of seed for sowing and application of germination stimulants break dormancy and improve germination for translocation.
  - Seed is desiccation tolerant and can be stored long-term, although there is a gradual decline in germination with storage time.
  - Seed priming techniques, germination-promoting compounds and timing of sowing (autumn) improve translocation success from directly sown seeds.
  - Propagation from cuttings of healthy, actively growing shoots in well-drained media will provide material for translocation purposes, however, plants are sensitive to watering regimes and cutting material must be supplied well in advance (~12 months) of *in situ* planting because it is a relatively slow growing species.

Background

Ricinocarpos brevis R.J.F.Hend. & Mollemans (Euphorbiaceae) has been declared as 'Rare Flora' under the Wildlife Conservation Act 1950 (WA), and as a 'Threatened Species' of flora under the Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth). *Ricinocarpos brevis* is a non-lignotuberous upright shrub from the Yilgarn Region of Western Australia and has been recorded in three populations located at the Windarling Range (where 18,112 individuals were recorded pre-mining, 11,198 individuals are extant), Johnston Range (est. 3,000 individuals) and the Perrinvale Range (2,982 individuals).

As part of an offset package to mine the Windarling Range W4 East Deposit, and remove 1,073 *R. brevis* individuals, Cliffs were required to undertake a 5-year research project with the aim of contributing a scientific understanding of the long-term recovery and protection of sustainable populations of *Ricinocarpos brevis* at the Windarling Range. This research project commenced in 2013 and was principally undertaken by the Botanic Gardens and Parks Authority (Kings Park Science) and the University of Western Australia (School of Biological Sciences).

Research program aims & framework

The aims of the restoration research program were to:

- To develop understanding, technologies and processes necessary for restoration of sustainable *Ricinocarpos brevis* populations at Windarling – whose functional attributes resemble those of natural populations (density, cover, genetic diversity, population processes and trend, and resilience to environmental variability).

- To develop measures, monitoring and analytical approaches to demonstrate that restored populations and their environmental attributes are, or are developing towards, those of sustainable natural populations.

- To develop a restoration manual for *R. brevis*.

Program objectives and outcomes achieved from research conducted by BGPA are documented in a range of reports, and summarised in Table 1.

This final report will be accompanied by a Restoration Manual for *R. brevis*, and is preceded by a series of annual reports, covering the years 2014-2017. Except for results presented in this report as the result of the last year of research, all results for the work are detailed in these four annual reports. The final results for those components that are presented in this report for the first time, chiefly outcomes of monitoring of longer-term experiments, are also listed in Table 1, and are described in full detail in their relevant sections.

Table 1: Structure of the research program and the objectives of each research theme. Shows the years that the research was carried out, the reference document for the relevant information, the overall outcome/recommendation and the agency responsible for the objective. (**NOTE**: Scope items written in grey are research modules undertaken by the Industrial Transformation Training Centre (ITTC) and not reported against in this document).

SCOPE			**Years carried out**	**Document reference**	**Outcome/ Recommendation**	**Agency**
Research Program Objectives	1. To develop understanding, technologies and processes necessary for restoration of sustainable *Ricinocarpos brevis* populations at Windarling – whose functional attributes resemble those of natural populations (density, cover, genetic diversity, population processes and trend, and resilience to environmental variability).		2013-2018	Annual reports 2014-2017 Final report 2018	Significant developments: • Appropriate technologies defined for *R. brevis* • *In situ* protocols for establishment identified • Ecological processes present and moderately functional	BGPA
	2. To develop measures, monitoring and analysis approaches to demonstrate that restoration populations and environmental attributes are, or are developing towards, those of a sustainable population.		2013-2018	Annual reports 2014-2017 Final report 2018	Abiotic and biotic measures were developed to monitor translocation success and maturation against natural plants/populations	BGPA
	3. To develop a restoration manual for *R. brevis*		2017-2018	Practitioner Restoration Manual	Restoration Manual developed for *Ricinocarpos brevis*	BGPA & ITTC
THEME 1 Interactions of *R. brevis* with its environment	1.1 **Species and population attributes**	Develop robust measures of key plant processes and functional attributes in natural reference populations. a) population demography b) floral biology c) pollination ecology c) reproductive capacity d) seed dispersal	2014-2018	Annual reports 2015-2017 Final report 2018	a) limited recruitment b) outcrossed and sensitive to temperature c) generalist community of pollinators d) highly sensitive to seasonal conditions e) gravity or ant dispersed	BGPA

SCOPE			Years carried out	Document reference	Outcome/ Recommendation	Agency
		Monitoring and experimentation of the ecophysiological behaviour of *R. brevis* in natural populations. a) seasonal and daily patterns of water use b) drought tolerance, avoidance capacity or strategies	2017-2018	ITTC		ITTC (lead) + BGPA (assist)
	1.2 **Environmental attributes**	Analysis of soils in natural populations a) physical b) chemical c) hydrological properties d) seasonal temperature and moisture	 2013-2014 2013-2014 2013-2014 2013-2018	Final report 2018 Annual report 2014 Annual report 2014 Annual report 2014 Annual reports 2014-2017	a) variable but similar texture b) variable chemistry c) variable but similar hydrological properties d) site aspect affected soil temperature and moisture	BGPA
		Species distribution modelling (SDMs) of *R. brevis* will be performed based on: a) spatial data that already exists b) supplemented by the additional newly created (e.g. fire history) or calculated (e.g. solar radiation and curvature) from topography in a GIS. Surface and landscape features such as slope, radiation receipt and litter cover will also be recorded.	2017-2018	ITTC		ITTC (lead) + BGPA (assist)
	1.3 **Vegetation community**	Determine whether there is any weak or strong correlation between the occurrence of *R. brevis* with other native species within the Windarling and Johnston Range (Perrinvale?) populations.	2017-2018	ITTC		ITTC
		Factors governing these relationships *in situ* and *ex situ* investigations will be undertaken to determine the nature of these relationships in terms of plant growth, health, drought tolerance and resilience	-	ITTC	Time and rainfall dependent Dependent on propagating material	ITTC
		Assess development of root architecture a) propagation container b) effect of drought	-			ITTC

SCOPE			Years carried out	Document reference	Outcome/ Recommendation	Agency
THEME 2 Optimising the restoration environment for *R. brevis*	2.1 **Species attributes**	Monitoring and experimentation of the ecophysiological behaviour of *R. brevis* in translocated populations. a) seasonal and daily patterns of water use b) drought tolerance, avoidance capacity or strategies	2017-2018	ITTC		ITTC (lead) + BGPA (assist)
	2.2 **Environmental attributes**	Analysis of soils in translocated populations a) physical b) chemical c) hydrological properties d) seasonal temperature and moisture	2013-2014 2013-2014 2013-2014 2013-2018	Final report 2018 Annual report 2014 Annual report 2014 Annual report 2014 Annual reports 2014-2017	Information under Section 1.2	BGPA
		Test site amendments in their capacity to support the establishment and growth of *R. brevis*. a) fencing b) fertiliser c) shade d) irrigation	2013-2018	Final report 2018 Annual reports 2014-2017	a) improves translocation survival and growth b) mixed improvement for translocation success c) improves translocation survival and growth d) improves translocation survival and growth	BGPA
		Design *in situ* substrates (been dependent on availability) and the functional properties of these designed materials will first be tested directly, and then their capacity to support the establishment and growth of *R. brevis* plants will be tested in field planting trials. Undertake analysis of the availability (e.g. cost, stability, storage, transport, timing) of the materials used to design a range of restoration materials substrates.	Activity was dependent on availability of substrates, machinery and personnel to transport materials on site	Research Proposal (original & revised) 2012/2013	These on site resources were unavailable at the proposed time of implementing research program Recommend no pursuit of this as future research - Standard practises of using existing substrates resulted in plant survival	BGPA

SCOPE			Years carried out	Document reference	Outcome/ Recommendation	Agency
THEME 3 Optimising *R. brevis* plant establishment in restoration	3.1 **Topsoil research**	Complete an audit of topsoil from directly under *R. brevis* plants under natural conditions.	2017-208	Final report 2018	Seed is dispersed away from plants by ants	BGPA
		Undertake an assessment of different topsoil deposits at different depths. a) W1 pit area (stockpiled Sept 2012) b) W1 pit area (stockpiled May 2013) c) W4 East pit (stockpiled Jan 2013) d) already on rehabilitation	2013-2014	Annual report 2014	Topsoil is a poor source of seed for *R. brevis* translocation Topsoil is a critical media for translocation activities	BGPA
		Sub-sample of topsoil to be waterproofed and comparatively assessed against uncovered topsoil.	Dependent preceding results	Research Proposal (original & revised) 2012/2013	Deemed inappropriate activity as *R. brevis* did not germinate from topsoil (Annual report 2014)	BGPA
	3.2 **Seed Science**	Assess seed purity and seed viability of target species following collection and cleaning.	2013	Annual report 2014	Seed quality varies among seasons of collection	BGPA
		Establish baseline seed germination and dormancy traits for *R. brevis* a) standard test conditions b) presence/absence of dormancy c) classify the type of dormancy d) methods of alleviating dormancy e) seedbank dynamics (burial-retrieval trials)	 2013-2014 2013-2014 2013-2014 2013-2015 2014-2018	 Annual report 2014 Annual report 2014 Annual report 2014 Annual report 2015 Annual reports 2014-2015 Final report 2018	a) cool temperatures and burial improve germination b) dormant seed c) physiological dormancy d) all germination stimulants alleviate dormancy e) seed persists in soil seedbank (min 2-3 yrs)	BGPA
		Develop methods of seed banking for both longer-term conservation and shorter-term storage. a) desiccation tolerance b) freeze tolerance c) effect on dormancy status and germination	 2014-2017 2014-2017 2014-2017	Annual reports 2014-2017	a) desiccation tolerant b) tolerant of certain freezing c) declines over storage time, but can be stored long-term	BGPA

SCOPE			Years carried out	Document reference	Outcome/ Recommendation	Agency
		Develop seed enhancement techniques to increase the effectiveness of broadcast seeding by improving site delivery techniques and seedling establishment. a) seed priming techniques b) germination promoting compounds c) anti-stress agents d) time of sowing (summer, autumn, winter)	 2013-2017 2013-2017 - 2013-2015	Final report 2018 Annual reports 2014-2017	a) improve translocation emergence b) improve translocation emergence c) dependent on obtaining a large collection of fresh seed d) early break (autumn)	BGPA
	3.3 **Greenstock Program**	Optimizing plant production under nursery/culture conditions. a) propagation material b) propagation media c) propagation maintenance d) commercial suppliers	 2014-2016 2014-2016 2014-2015 2014-2017	Annual reports 2014-2017	a) healthy, actively growing softwood shoots b) well-drained, organic and non-organic mix c) sensitive to watering regime d) supply material well in advance of translocation	BGPA
		Plants derived from nursery production will be transplanted into restoration sites and exposed to a range of treatments. a) fencing b) fertiliser c) shade d) irrigation	2013-2018	Final report 2018 Annual reports 2014-2017	Information under Section 2.2	BGPA

Theme 1: Interactions of *R. brevis* with its environment

For this research theme, BGPA set out to understand the natural population dynamics of the threatened species by identifying specific target attributes of natural populations, including their density, rates of growth, survival, viable seed and seedling production and seed bank accumulation and persistence, and considering their variation in relation to environmental variation and age. In addition, BGPA sought to understand the role and significance of key biotic associations associated with *R. brevis* – pollinators, dispersers, seed predators, herbivores, pests, competitors and common associates.

Ecological and population sustainability is a major aim of restoration programmes. Understanding the biotic (**species and population attributes, vegetation communities**) and abiotic (**environmental attributes**) interactions of a species with its environment in an integral part of assessing and achieving sustainable restoration (Miller *et al.* 2017; Perring *et al.* 2015).

1.1 Species and population attributes

Background

Identification of the biotic attributes of a species and their interaction with other species in the system is key for assessing the success or trajectory of restoration and its integration with the surrounding landscape. Developing robust measures of key plant processes and functional attributes in natural populations provides the benchmark to which evaluations of restoration effort can be compared against to determine what level the new population is functioning at in relation to these reference populations.

Population demography

OBJECTIVE Quantify the structure, age and recruitment dynamics of natural populations

Ricinocarpos brevis plants were measured at Windarling Range and Johnston Range to assess population demography. Five plants that were removed as part of the mining process, and salvaged as part of a transplant rescue attempt (2013) but which subsequently died and were then used as specimens for herbchronology and dendrochronology. This was undertaken with support from University of Western Australia (UWA) and the Australian Institute of Nuclear Science & Engineering (AINSE).

There were three methods used to assess population demography:

1. Estimate of plant size and growth
    a) label and monitor 20 plants per site
    b) measure plant size (height × width × perpendicular width)
    c) measure stem diameter (base above soil surface)
2. Estimate of plant age
    a) count of growth rings under a binocular microscope
    b) radiocarbon dating of specimens (AINSE facilities)
3. Observations of seedling recruitment
    a) monitor permanent plots (in 5 × 5 m subplot with 1a.)
    b) check for seedlings annually during spring.

Ricinocarpos brevis populations at Windarling Range and Johnston Range had a similar distribution of plant size class structure. The majority (70%) of sampled plants were less than 2.5m^3 at both sites, with the remaining plants at Windarling having a smaller range in volumes (2.5-10m^3) than Johnston (2.5-15m^3). The average number of stems on a plant was lower at Windarling than Johnston. At both sites, the distribution of plant sizes changed between 2014 and 2015, demonstrating the capacity of *R. brevis* individuals to survive harsh conditions by retracting growth from smaller, vulnerable branches to the larger, robust branches in periods of unfavourable conditions (e.g. limited water availability). It is not an uncommon phenomenon for plants in semi-arid/arid areas to be considered 'semi-deciduous', as they cope with environmental pressures and shed leaves in response to poor environmental conditions (Garcia *et al.* 2017).

Herbchronology (i.e. counting of growth rings) assessment showed the 'relative age' range of plants to be 32-100 growth rings or growing periods during the life of the plant. Growth rings were small and densely packed, which indicated a sensitivity in growth that may be due to highly variable rainfall or moisture sensitivity (i.e. arid, steep and rocky slopes; Stokes and Smiley 1996). Dendrochronology (radiocarbon dating at the Australian Institute of Nuclear Science and Engineering - AINSE) validated the age of the specimens (~40-150 years old) and confirmed that growth rings or stem diameter does not accurately correlate to plant age for this semi-arid species but rather reflect intermittent opportunistic times of growth that may only occur every few years or so.

From 2013 to 2016, there was no recruitment observed of *R. brevis* seedlings in the monitoring plots at Windarling Range or Johnston Range. Cliffs had a greater monitoring coverage at Windarling Range (ten transects across ~2.7km of ridgeline) and recorded <0.0025% seedling recruitment (of the total number of plants surveyed) for 2014 and 2015 (Cliffs Asia Pacific Iron Ore, 2015). This indicated that the window of opportunity for *R. brevis* seedling recruitment is very narrow and infrequent in occurrence. Other research has drawn similar conclusions about limited species recruitment opportunities and survival capacity in similar water-limited environments (Yates *et al.* 2011; Yates *et al.* 2007). No monitored plants, including seedlings, died during the course of the study. Observations of plants outside of plots showed a sometimes-significant impact of mammalian herbivores on seedling survival.

Recommendations from population demography

- Plants are long lived, with varying growth rates and low recruitment.
- Recommend continued feral fauna controls (e.g. rabbits) to protect the species from grazing pressures.
- Natural recruitment processes are not frequent in this environment, so recommend ongoing monitoring of population demography and long-term monitoring sites (as already undertaken by Cliffs), that is focused on identifying natural recruitment windows and adult plant mortality.

Floral biology

OBJECTIVE
Identify the stages floral development and determine the breeding system of *R. brevis*

Monitoring of floral development occurred under controlled conditions (with plants grown in the glasshouse at BGPA). Plants were reproductively mature in 2015 (plants germinated in 2013; i.e. ~2 years old). Floral development of individual flowers was tracked on three plants in 2015 and 2016. Floral development on entire plants was monitored on 20 plants in 2015 and

50 plants in 2016. Hand-pollinations occurred on eleven plants in 2015 (total of 110 flowers) and twelve plants in 2016 (total of 460 flowers). Hand-pollinations occurred on only one plant in the field in 2015 (total of 40 flowers) due to the poor availability of suitable flowers at the time of visitation.

There were two methods used to characterise floral biology:

1. Observations of floral development
    a) flowers on glasshouse plants were tagged
    b) the stage of individual flower development was recorded daily (e.g. bud, opening, fully opened)
    c) the number of flowers on a single plant were counted weekly (e.g. bud, male or female)
    d) temperature was recorded on monitoring days (Perth daily maximum)
2. Hand-pollinations under controlled (glasshouse) and *in situ* (field) conditions involved the following set of pollen crosses:
    a) control (flower not pollinated and bagged to prevent natural pollination)
    b) self-crossed (pollen taken from male flower and placed on female flower of same individual)
    c) outcrossed (pollen taken from male flower of one individual and placed on female flower of a different individual)

Plants grown from seed that were >2 years old flowered under glasshouse conditions. The first season of flowering results in only a small number of flowers. Floral development of male and female flowers was temperature sensitive, with flowers developing from bud to maturity faster when it was warmer (2-3 days, 29-42°C) than when temperatures were cooler (4-5 days, 16-29°C). Male flowers matured anthers sequentially, from the base of the floral stalk to the top and were considered fully mature when anthers at the top of the floral stalk were open and releasing pollen (Figure 1d). Female flowers were considered receptive when the styles had fully extended past the width of the ovary (often curled or bent; Figure 1c).

Ricinocarpos brevis is monoecious, with separate male and female flowers that develop in cycles on the same plant, with the first gender of flowers giving way to the alternate gender later in the flowering period, often with an overlap of both genders occurring at the same time. The flowering season in the glasshouse occurred from early October to late January. This was later than *in situ* plants, which have been recorded to flower (May-July; DEC 2011), and was attributed to temperature and/or rainfall differences between coastal and semi-arid regions of Western Australia.

Hand pollinations on *R. brevis* plants in the glasshouse did not produce any fruit. Several reasons for this could be due to poor hand pollination technique, age of plants and ability to set fruit or environmental conditions under glasshouse surroundings (too hot or cold for pollen germination). Hand pollinations in the field showed that flowers did not set fruit when pollinators were excluded (by bagging) but did produce fruit when flowers were manually outcrossed.

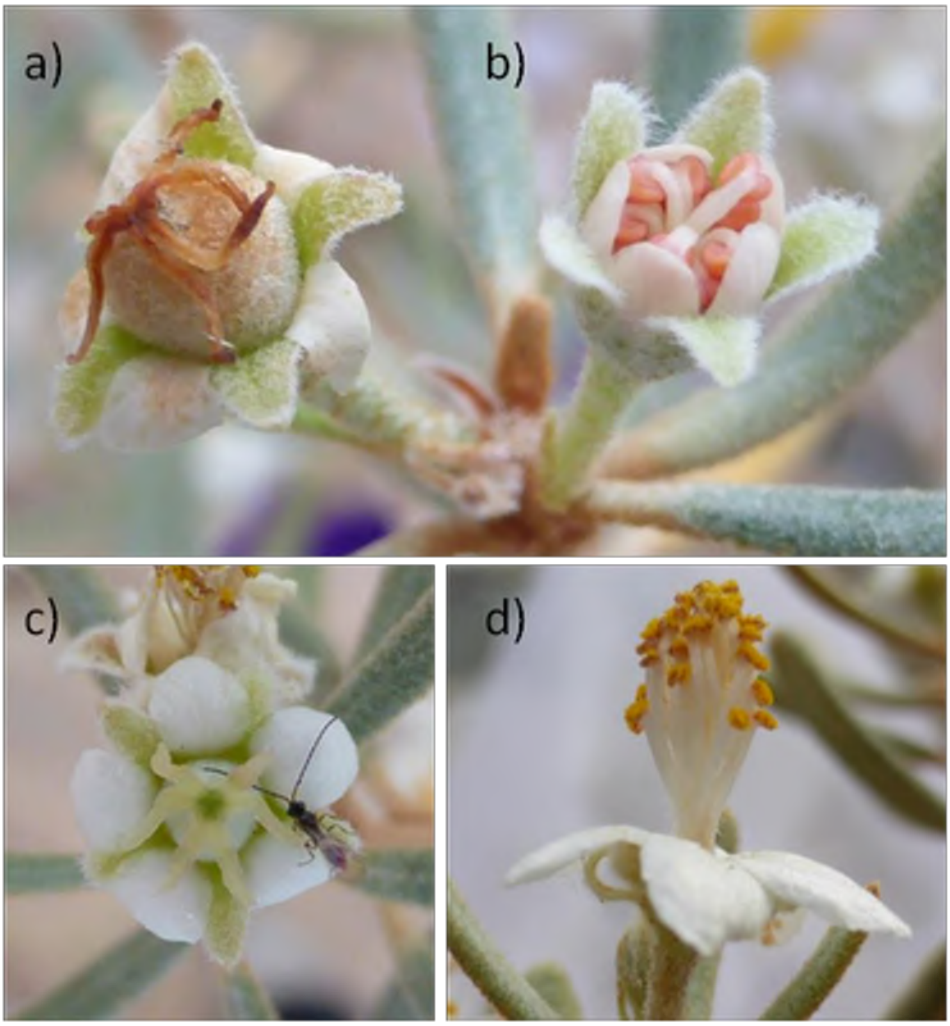


Figure 1. The floral development stages of *Ricinocarpos brevis*. a) female flower with stigmas that are past receptive stage; b) male flower with emerging anthers that have not released pollen; c) female flower with receptive stigmas and a visiting insect; and d) male flower with all anthers having shred their pollen.

Recommendations for floral biology

- *Ex situ* plants will begin to produce flowers from around two years of age.
- Flowers of *R. brevis* are entirely dependent on pollinators for pollination (i.e. monoecious biology with separate male and female flowers and results from the *in situ* exclusion experiment).
- Fruits were observed on *ex situ* plants at three years of age (unmanipulated flowers).
- Flower initiation, fertilisation and seed production will depend on abiotic factors (temperature sensitive floral development).
- Recommend that any translocation or seed orchard be comprised of many unique genotypes to encompass all variation in floral phenology (timing of male and female flowers) and age to ensure that there are many plants available to pollinate each other at any one time.
- Flowering phenology of plants located in environments that are more temperate (i.e. BGPA) shifted in comparison to naturally occurring plants found at Windarling Range environment. It is recommended that plants reared under *ex situ* conditions be tracked (timing of flowering and fruiting) when translocated to natural semi-arid sites, to determine if this shift in flowering time is plastic or fixed and consequently impacts on the capacity of natural and nearby translocated populations to exchange pollen.

Pollination ecology

OBJECTIVE Identify likely pollinators and their floral visitation rates, and determine the composition of insect communities in different habitats

Potential pollinators were observed visiting flowers of plants at Windarling Range for two consecutive years (2015, 2016) during the peak flowering season (June). In addition, Malaise traps (total of ten traps) were set up in four landform types (total of seven sites) where *R. brevis* was either: 1) naturally present (Windarling and Johnston Ranges); 2) naturally absent (Mt Jackson); 3) unlikely to occur (Pigeon Rock Plains and W2 South Plains) and; 4) likely to be restored to (waste rock landform: W2 South and W2 North). Traps were set seven times seasonally between August 2014 and November 2015.

There were two methods used to assess pollination ecology:

1. Observations of floral visitors
    a) full day monitoring during peak flowering
    b) two observers for two consecutive days, two times a year
    c) recorded type of insect visitor, type of flower visited, number of flowers visited, the number of plants visited and time taken
2. Trapping flying insects
    a) set up Malaise traps on warm sunny days
    b) traps were set up seasonally (once every three months)
    c) traps were open for three to four days before insects were collected
    d) insects were swabbed for pollen
    e) pollen was identified against a library, which was the collection of pollen from any plant in the general area that was flowering during trapping

Thirteen morpho-species of arthropods were observed visiting both male and female flowers of *R. brevis* (honeybee, black fly or midge, wasp, beetle, ant, moth and spider). Except for spiders, all of these arthropods were observed with pollen on their bodies and could potentially be classed as a pollinator. Floral visitation patterns generally involved insects visiting multiple flowers on a single plant before moving away from view, with the honeybee and moth observed moving between multiple plants. The honeybee and ant were the most frequent floral visitors during 2015 observations and the moth and ant during 2016 observations.

Flying insects were trapped in all four landforms or habitats, with the highest abundance of insects being trapped in the restoration sites. Limited pollen was able to be swabbed from these insects and none of it was from *R. brevis*. The composition of the insect community (identified to family level) varied among habitats, but each contained a similar number of insect families (8-10 families).

Recommendations for pollination ecology

- Fertilisation or seed production depends on biotic interactions, with pollination occurring via a variety of insects that visited flowers, recommend monitoring to translocations to ensure pollinators are visiting translocated plants as they begin to flower.

- Recommend floral visitation observations as the best method for determining potential pollinators of the species.
- Recommend Malaise traps to determine the composition of the flying insect community in different landforms or vegetation types to determine extent of similarity/dissimilarity among insect communities.
- Male and female flowers are visited by many species of insect that indicate a generalist pollination system, recommend restoration efforts include a broad range of indigenous flowering plants (floral type and timing of flowering) that may support and enhance this diverse pollination community.

Reproductive capacity

OBJECTIVE Quantify the reproductive capacity of mature *R. brevis* plants in natural populations

The reproductive status and quantity of flowers or fruit was measured on mature plants at Windarling Range and Johnston Range. Plants were monitored at both sites over three seasons (2014-2016).

There were several methods used to assess the reproductive capacity of plants.

1. Monitoring of reproductive adults in the field
    a) 20 plants at each site were randomly selected and tagged
    b) three branches on each plant were randomly selected and tagged
    c) number of flowers (bud, male or female) were counted on each branch during peak flowering (winter/spring)
    d) number of fruits were counted on each branch just before maturity and dehiscence (late spring/ early summer)
2. Collection and assessment of fruit and seed set
    a) 5-15 fruit^ collected off each of the 20 plants (early to mid-summer)
    b) fruit were air dried (> one week) before being opened to extract seed
    c) number of seed and predated seed per fruit counted and quantified

d) extracted seed were exposed to x-ray assessment (Faxitron Seed Imaging system) and scored depending on the presence of endosperm and an embryo to determine percentage seed fill (viability)

^ Less if it did not meet licensing requirements (i.e. no more than 10% of an individual)

The reproductive capacity of *R. brevis* was variable and highly dependent on the amount of rainfall received, leading up to and during the reproductive season. Plants at Windarling Range generally had a greater reproductive capacity than those at Johnston Range, which may have been due to variation in rainfall between the two sites (~40km apart). Over three years (2014-2016), monitored plants did not convert all female flowers produced into fruit, as the number of flowers produced on a single branch was always higher than fruit set (7.2-28.2 flowers per branch and 0.3-7.9 fruit per branch). The expected number of locules produced for each fruit was three, but there were examples of fruit with two, four or five locules. Seed quality and quantity varied between Johnston Range and Windarling Range, with a significantly smaller seed weight and lower quantity of seed produced on plants at Johnston Range. Based on observations of collected fruits and seeds, seed were vulnerable to predation pressures in the form of moth or wasp larvae which consumed developing seed. The proportion of a crop that was predated was also dependent on the amount of rainfall for the season and ranged from 3-15% of the seed crop for that year.

Recommendations for reproductive capacity

- The reproductive capacity, that is the production of flowers, fruit and seed, is highly variable spatially (Windarling vs Johnston Ranges) and temporally (2014 to 2016) and appears to be dependent on environmental factors, particularly the timing and duration of rainfall leading up to and during the peak flowering season of *R. brevis*. Recommend yearly monitoring of several reference plants (~10) in the natural population for direct comparisons to be made to any translocated plants in the same season (ideally plants of similar size) to assess reproductive trajectory of translocated populations.
- Recommend that seeds be collected over multiple years to capture suitable seed quantity and quality for *in situ* or *ex situ* collections.

Seed dispersal

OBJECTIVE
Identify seed dispersers and quantify their dispersal capacity, and determine the composition of ant communities in different habitats

The seeds of *R. brevis* possess a well-developed lipid/protein-rich aril (in Euphorbiaceae this is termed a caruncle) that is commonly associated with ant mediated seed dispersal (termed "myrmecochory") (Lengyel *et al.* 2010). To determine the role of ants in dispersing *R. brevis* seeds, surveys of ant communities were conducted in four landform types: 1) *R. brevis* naturally present (Windarling and Johnston Ranges); 2) *R. brevis* naturally absent (Mt Jackson); 3) *R. brevis* unlikely to occur (Pigeon Rock Plains and W2 South Plains) and; 4) potential *R. brevis* translocation sites (waste rock landform: W2 South and W2 North). Observations of seed dispersers were assessed during peak seed maturity and seed release of *R. brevis* plants (2014) in two landform types (number one and four). Surveys of ant middens occurred after seed release (November-December) in three years (2014-2016) at sites in landform type one only.

There were three methods used to assess the functional role of ants as seed dispersers.

1. Ant species community surveys (two collectors)
    a) 20-30 minutes of searching each area, repeated four times on different days
    b) collecting ant specimens via a pooter and preserving in ethanol (70%)
2. Cafeteria experiments
    a) four petri dishes containing a known number of *R. brevis* seed (15 seed), monitored by one observer
    b) petri dishes were observed and ant activity recorded (i.e. visit but not remove seed or remove seed)
    c) three observers monitored petri dishes for the entire day at a site, moving the petri dishes after ant activity was recorded at a dish
    d) ants that removed seed were tracked to their nest and the distance from the dish to the nest recorded (GPS)
    e) temperature and other conditions were recorded for each survey day
3. Ant midden surveys
    a) each area was searched for ant middens (refuse pile outside an ant nest)
    b) ant middens were collected and *R. brevis* seed removed under a microscope

c) seed were counted and x-rayed to assess viability

The composition of ant communities was dynamic and variable across the landscape, and restoration sites showed a similar level of ant species richness to natural sites (total of 43 ant species), however, all sites were dissimilar in species composition from each other (i.e. different communities at each location).

There was a significant functional role played by ants in the dispersal of *R. brevis* seeds and thirteen species were identified as seed dispersers from the cafeteria experiments. The capacity of this role was more prominent at the naturally occurring populations (51-80% seed removal rate) than restored sites (6% seed removal rate). Observed ant dispersal distances ranged from 1cm to 110m and followed the pattern of a typical dispersal curve (frequent short-distance dispersal decreasing to infrequent long-distance dispersal). Restoration areas (>5 years old) have been colonised by an ant community that was capable of dispersing *R. brevis* seeds, however, the extent to which this functional role occurred was significantly reduced in comparison to the natural populations.

Ant middens within *R. brevis* populations contained *R. brevis* seed (ranged from 0 to 102 seed) and was highly dependent on the amount of seed that plants produced for that season and whether the ants had finished with the seed. These ant middens contained viable and non-viable seed, with the aril missing from all of them.

Recommendations for seed dispersal

- Passive seed dispersal via ants will not bring *R. brevis* seed into restoration areas (>110m from natural sites), seed must be manually brought into restoration areas.
- Seeds should be buried just below the surface to avoid ant dispersal at early stages of restoration, only if this does not negatively affect seed germination (see Section 3.2).
- Ongoing monitoring of the development of ant communities in restoration areas to:
    - track the maturity of the ant community against the natural reference sites (species richness and abundance);
    - determine what characteristics would support a more functional ant community for *R. brevis* (e.g. habitat assessments);

    - quantify the interaction and impact of seed dispersal on restored *R. brevis* populations as they mature and begin to produce seeds (cafeteria and midden assessment).
- Monitoring of restoration areas for *R. brevis* seedlings that may have dispersed away from seeding plants as restoration matures (i.e. seedlings emerging from ant middens).

1.2 Environmental attributes

Background

Identification of the abiotic attributes of a species' environment is key for assessing the success or likely trajectory of restoration and its integration with the surrounding landscape. Abiotic impediments to seedling germination, emergence establishment or survival need to be identified in natural and restored area soil profiles to understand natural recruitment dynamics and amend altered soil profiles accordingly to improve restoration success (Marrs 2002). Quantifying and comparing the abiotic environment where *R. brevis* occurs with the proposed new location of plants is key to anticipating its requirements and ameliorating the restoration environment to improve success.

Soil substrates

OBJECTIVE
Characterise the chemical, physical and hydrological properties of natural and disturbed soils

Soil samples (2 kg each) were collected from ten sites (2013) that encompassed different geology, geomorphology and aspect, and could be broadly grouped as sites where *R. brevis* plants were present (five sites) and where *R. brevis* plants were absent and the soil was disturbed (five sites).

Soil substrate characteristics were assessed through various methods and included:

1. Chemical assessment to define:
    a. Chemical state (EC and pH)
    b. Key elements (Org C, N, P, S, Fe)
    c. Trace elements (Al, B, Ca, Co, Cu, K, Mg, Mn, Mo, Na, Ni, Zn, As, Se)
2. Physical assessment to define:

a. Soil texture with a laser diffraction particle sizing machine
b. Gravel content through fraction separation
c. Soil-water relationships by estimating a soil moisture characteristic curve

The natural sites of *Ricinocarpos brevis* and the restoration areas had a similar texture (loamy sand) and gravel content, except that sampled restoration areas had a higher fines content. Surface soils of the waste dump may have been sourced from a variety of locations, including slopes and flatter areas disturbed during clearing activities. Water storage capacity was similar among natural and restored areas, except one natural site (Johnston Range) with the lowest soil water storage capacity of all the samples assessed. Chemical properties differed among natural sites and between natural and restored areas. The major differences included higher iron, calcium, nitrogen, and organic carbon at most of the natural sites near the restoration areas, however, the alternate natural population of *R. brevis* (Johnston Range) did not have the same magnitude of difference in these characteristics and therefore there was no consistency among characteristics that would indicate recommendation of chemical or physical amendments to potential *R. brevis* translocation sites in the future.

The topsoil layer (10-20cm) placed on the waste may be likely to have similar properties to the natural soils as these are collected from cleared sites. The (physical, chemical, hydrological and biological) attributes of fresh and ageing waste material underneath the topsoil may also be a limiting factor to long term plant growth and survival. This nature of this material, and impacts of variation in this material on developing and older plants was not assessed as part of this study.

Recommendations for soil substrates

- Recommend no amelioration of basic soil properties on waste rock landforms, if appropriate topsoil application (10-20cm) is applied to these restored areas, due to the relatively similar chemical and physical properties of waste rock landforms with natural soils.
- Confirm source of topsoils (if known) used in translocation areas
- Testing the properties of waste materials underlying translocation sites may provide useful information for understanding limitations to plant establishment and growth.
- Recommend monitoring of soil chemical and physical properties to ensure soil substrates are stable and do not change substantially over time.

Soil environmental profile

OBJECTIVE
Quantify the spatio-temporal variation of soil moisture and temperature in natural and disturbed soils

Temperature and moisture probes were placed in soil to characterise the environmental profile of natural and disturbed sites. There were two natural sites 1) Windarling Range and 2) Johnston Range, and four disturbed sites 1) waste rock landform north-facing aspect (W2N), 2) waste rock landform south-facing aspect (W2S), 3) waste rock landform south-facing aspect (W3S), and 4) an exploration drill pad (W3) that were monitored during the project. A total of nine data loggers were set up and monitored at various times over the duration of the research program.

Method for soil profile assessment:

1. Soil environmental conditions were measured using temperature (°C) and moisture (m^3/m^3) soil probes:
    a) buried at different depths (2cm to 50cm) below the soil surface
    b) data was recorded every hour for 12 months
    c) data was logged and regularly uploaded using an Onset HOBO data logger (Model H21-002)

The average change in soil temperature between day time and night time temperatures varied across the sites and across seasons (Figure 2). For example, there were differences between the two natural sites with Windarling Range having a smaller change in temperature and soil moisture between the day and night for April and May than the Johnston Range site. The variation in temperature change on the south facing slopes was intermediate between the two natural sites, whereas the north facing slope and drill pad had a temperature change that was higher than both natural sites. With regards to change in soil moisture, one south facing slope was similar to Windarling Range and the other two south facing slope and the drill pad were similar to data recorded from the Johnston Range. Again, the north facing slope had a more severe change in soil moisture content than any other site. In summary, the natural and south facing slope sites appeared to have below ground conditions that fluctuated less over the course of 24 hours than the north facing or drill pad sites (Figure 2). Along with seasonal rainfall, this may have contributed to the differences observed in plant health and survival among the sites.

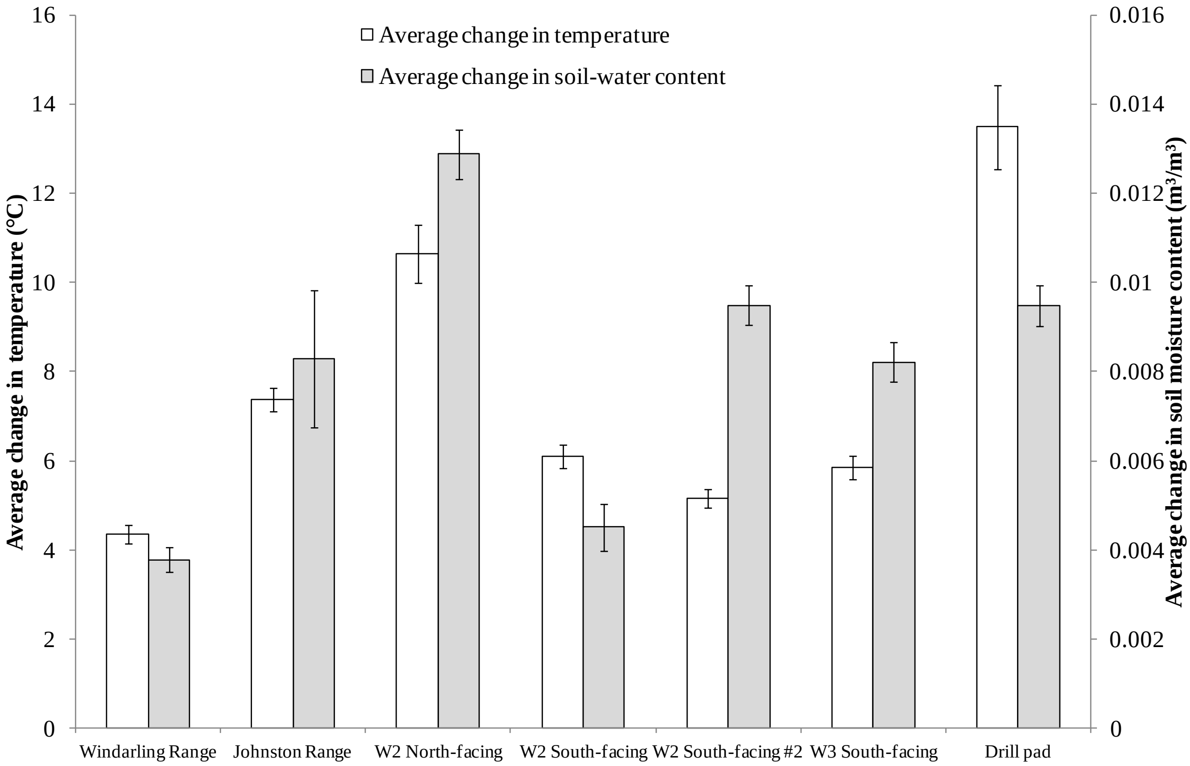


Figure 2. The average daily change in temperature between day and night for April-May (white bars) and the average daily change in soil moisture content between day and night for April-May (grey bars). Standard error bars presented.

Recommendations for soil environmental profile

- Recommend translocation sites to be on south facing slopes of waste rock landforms.
- Monitoring of soil environmental profiles (temperature and soil moisture) are critical to the assessment of translocation success and understanding how belowground processes impact on aboveground plant survival.
- Given the more extreme soil temperature and soil moisture fluctuations in some sites, it is recommended to assess the use of treatments proven to ameliorate suboptimal soil temperature and moisture conditions (e.g. mulch, nurse species, shading, etc.). These may further enhance the use of the preferred planting sites (e.g. southern facing slopes).
- Recommend implementation of larger scale site amendments for translocation sites in less stable soil environmental profiles, like north facing slopes or drill pads. This may be achieved through a greater shading of restoration area, increased application or

frequency of irrigation and/or research into the effects of a ground cover (mulch or nurse species) on plant survival.

Theme 2: Optimising the restoration environment for *R*. brevis

For this research theme, BGPA set out to identify the environmental attributes necessary for plant establishment and survival, and understanding the environmental stresses imposed on plants that affect these outcomes. This included investigations of soil characteristics, ameliorate the variation in temperature or soil moisture and enhance landform aspect.

Identification of the conditions necessary for the establishment and persistence of a species through the determination of the key variables limiting the current population distribution will be essential to improve the restoration success for *R. brevis*. Knowledge of these attributes will improve the foundations of restoration through more focused site selection and assist in engineering other features of the site to improve overall restoration success and ensure that plants in translocated populations are functioning in a similar way to plants found in natural sites (Miller *et al.* 2017).

2.2 Environmental attributes

Background

Generating plant material for restoration purposes requires an **understanding of the stresses imposed** on the plants in the site to be restored. In semi-arid environments, different strategies for coping with low soil water and high atmospheric evaporative demand may contribute to differences in the competitive ability and the distribution of species (Damesin *et al.* 1998). In these environments, seedlings must survive the inherently long, hot dry summers (Roche *et al.* 1998) with an immature root system that has limited access to soil water (Cavender-Bares and Bazzaz 2000; Donovan and Ehleringer 1991). Irrespective of climate, transplanted seedlings or tubestock commonly suffer water stress that can limit early growth or cause high levels of mortality (Close *et al.* 2005). Therefore, optimising site attributes relating to runoff and erosion rates, water infiltration and storage and evaporative losses is important to enhance the establishment and survival of restored plant communities.

Site amendments

OBJECTIVE Determine the effect of site amendments on the performance of seedling emergence and tubestock survival

The following method outlines the site amendments tested during translocation trials to develop *in situ* approaches that can be implemented in the field to improve seedling emergence from directly sown seeds and tubestock establishment of *R. brevis*.

Translocation field trials (2014 - 2017) involved implementation of various site amendments to enhance in situ germination, seedling emergence, plant survival, growth and overall health. Each site amendment or combination of site amendments had suitable replicates that were compared back to a control (see Appendix 1 for the experimental design of each translocation trial). There was one natural site Windarling Range, and three disturbed sites 1) waste rock landform north-facing aspect (W2N), 2) waste rock landform south-facing aspect (W2S), 3) waste rock landform south-facing aspect (W3S) that were used and monitored during the project for translocations (Figure 3).

Site environmental characteristics assessed for plant stress and amendments treatments included:

1. Slope aspect: north and south facing areas (Figure 3)
2. Landform type: natural or disturbed (Figure 3)
3. Fencing: plot fencing and/or individual caging (Figure 4)
4. Drip irrigation of seed and plants via a gravity fed system that delivered 7.5-10mL of potable water per watering time. The irrigation frequency tested included:
    a) once every seven days or
    b) once every three days and
    c) ceased after 8-9 months (autumn) or
    d) ceased after 12 months (winter)
5. Shading of plants with a 50% shadecloth guard (Figure 4)
6. Fertiliser: Osmocote for native plants (~1Tbsp/plant)
7. Water crystals: Hydro-beads (4Tbsp to 8L soil; Advanced Fertiliser Technology)

During translocation trials soil environmental conditions were regularly monitored (i.e. soil temperature and soil moisture) using several Onset HOBO data loggers (Model H21-002) fitted with temperature and moisture probes that were buried 2 to 50 cm below the soil surface. Soil conditions were recorded hourly for 12 months with data downloaded on a regular basis.

Ricinocarpos brevis responded well to certain site amendments that increased emergence, survival and growth of emerging seedlings and tubestock. In a previous trial by Cliffs, it was observed that plants were vulnerable to grazing pressures (vertebrates; Cliffs pers. obs.), so all translocations were protected through **caging**. Slope **aspect** influenced environmental conditions (see Section 1.2) and emergence was only recorded on the south facing slope in 2013 and 2014. **Landform type** influenced plant establishment, as no tubestock survived planting into the natural environment. Assessment of **soil environmental conditions** associated with aspect showed that a north facing aspect had higher average daily soil temperatures than the south facing slope or natural ridgeline (see Section 1.2). Frequent **irrigation** (every three days) for 9-12 months of broadcast seed and tubestock increased emergence by 2-5% and survival by 5-12% respectively. There was no difference in survival or growth when irrigation was turned off at 9 months (pre-summer) or 12 months (post-summer). **Shading** decreased the impact of transplant shock (3-4% less stress by visual health) and increased biomass growth (50-92%) on plants in general compared to those that were not shaded. The use of **fertiliser** had a mixed response in terms of growth, as those that were also shaded performed better than those that were only shaded or only given fertiliser. This indicated that fertiliser can be used in conjunction with shading to improve growth but should not be used alone. The use of **water holding crystals** did not significantly increase emergence of seedlings. There was early evidence that the use of water holding crystals was more beneficial to tubestock derived from seed than cuttings (less visual stress), however, shading and irrigation were the better site amendments for increased growth of tubestock. This indicated that water holding crystals may be used in conjunction with irrigation but by themselves are not likely to increase survival rates.

Figure 3. Translocation sites and years set up at Windarling: Windarling Ridge (2014, 2015); W2 waste landform north-facing aspect (2014); W2 waste landform south-facing (2014); W3 waste landform south-facing (2015, 2016, 2017); and W4 drill pad (2012 by Cliffs).

Figure 4. Plant guard used for the *R. brevis in situ* experimental seeding and tubestock trial to protect vegetation from grazing pressures. Top left and right: wire guard (33cm tall) and stakes; Bottom left and right: wire guard, stakes and shadecloth guard (>40cm tall).

Recommendations for site amendments

- Recommend caging to protect the species from grazing pressures (rabbits).
- Recommend translocations to be on southern aspects, as northern aspects have a harsher environment (temperature and moisture; see Section 1.2).
- Recommend the frequency of irrigation to be once every three days and for a duration that includes the first summer post-planting (see Section 3.3).
- Recommend shading of plants for greater biomass and survival, at least for their first summer.
- Further research could assess the benefits of surface rock cover (varying percentage and rock size) in rehabilitated landforms on shade, thermal, and soil moisture attributes at the plant scale.

Theme 3: Optimising *R*. brevis plant establishment in restoration

For this research theme, BGPA set out to develop techniques for optimising the establishment of *R. brevis* in restoration landforms. This involved investigating the best source of material, development of propagation methods and optimising conditions for *ex situ* maintenance and growth.

Species differ in the ease with which they can be established in restoration or maintained in an *ex situ* containerised plant collection. This results from factors such as their seed production, requirements for breaking dormancy, natural regeneration strategy (e.g. soil- or canopy-stored seed banks), sensitivity to the altered environment of restored substrates and *ex situ* environmental conditions and growing media. Understanding plant establishment, maintenance and growth is key to all restoration or translocation efforts.

3.1 Topsoil capacity

Background

Soil seedbanks of Declared Rare Flora have many advantages as sources of material for restoration, as they are genetically representative of original populations (often destroyed during the soil recovery process), and may be relatively easy to manage (if some specific requirements are met).

***In situ* soil seedbanks**

OBJECTIVE Identify the likely location of seed in the soil seedbank of natural populations and quantify the capacity for recruitment from the soil seedbank

Ricinocarpos brevis has myrmecochorous (ant dispersed – see Section 1.1) seed. It is expected that the majority of seeds that fall to the ground are removed and dispersed by ants (Section 1.1; Lengyel et al. 2010). Soil samples were collected from underneath *R. brevis* plants (total of 29 plants), random locations within the population (total of 20 samples) and targeted collections of ant middens (total of 20 middens checked). Samples were collected before (April) and after (November - December) seed dehisced from fruit and dropped off plants at Windarling Range and Johnston Range in 2017.

There were two methods used to assess quantity of seed in the soil seedbank. Soils were:

1. Manually screened under a microscope and any externally intact seed was x-rayed to determine the number of viable seed in the sample
2. Exposed to four standard treatments (glasshouse in April) to stimulate seed germination from the collected soil samples after exposure to the following treatments:
    a) water only (control)
    b) oven heat (80°C for one hour)
    c) aerosol smoke (one hour)
    d) oven heat and aerosol smoke (as previously described)

The first targeted assessment of the soil seedbank found limited numbers of seed (1-3 seed) underneath the canopy of *R. brevis* plants. Indicating that the soil seedbank largely resided elsewhere in the landscape (i.e. ant nests). A second targeted assessment of the soil seedbank found higher numbers of seed (10-100 seed) outside active ant nests, a number much higher than the initial soil seedbank assessment (i.e. ten middens). Germination of soil seedbank samples resulted in a low emergence rate (0-0.6 seedlings per sample) after 15 weeks, and no treatment effects were observed.

Stockpiled topsoil

OBJECTIVE Determine the capacity of stockpiled topsoil to be used as a source of material for *R. brevis* recruitment

Stockpiled topsoil, originally salvaged from the part of the *R. brevis* population that was removed, was assessed for a soil seedbank. Topsoil was stockpiled 6 to 18 months prior to assessment and it was expected to contain *R. brevis* seed as a source for restoration. A total of 40 samples from five different stockpiles were collected for assessment.

The method of assessment involved:

1. Testing soil from two locations in the stockpiled topsoil located on either the:
    a) surface or
    b) >25cm deep
2. Seeds treated and sown under glasshouse conditions in April after exposure to two standard treatments to stimulate seed germination from the soil, namely:
    a) water only (control)
    b) aerosol smoke (one hour)

There was no emergence of *R. brevis* seedlings from any stockpiled topsoil samples that were assessed as part of this experiment. This indicated that the quantity of *R. brevis* seeds in the soil seedbank was comparatively small in the large volume of stockpiled topsoil (i.e. 100s of cubic meters) and after many months of stock piling may have lost viability.

Recommendations for topsoil

- Use appropriate topsoil collection and storage protocols to ensure topsoil application for restoration contains as much of the biological function of soils as possible (e.g. diverse seedbanks, nutrients or microbes; (Golos *et al.* 2016; Muñoz-Rojas *et al.* 2016)).
- Monitoring restoration areas that used topsoil from *R. brevis* population for possible future seedling emergence.
- Do not prioritise the use of topsoil (stockpiled or targeted collection) as a potential source of *R. brevis* plants in future restoration programs.
- For future *R. brevis* translocation attempts, use alternative plant sources, such as direct seeding or nursery-grown tubestock.

3.2 Direct seeding optimisation

Background

Seeds are essential for mine restoration as in many cases they are one of the main components in re-establishing natural vegetation communities. Knowledge of seed biology greatly assists restoration practitioners and ensures that restoration is achieved in an efficient manner (Jiménez-Alfaro *et al.* 2016). *Ex situ* programs such as seed banking (capturing a genetically representative sample of germplasm) and seed enhancement technologies (that increase and enhance seed germination performance, seedling establishment and stress tolerance) require basic research to develop and optimise techniques, and in future these programs are likely to be critical to restoration success.

Several issues for seed collection were addressed prior to this research:

- Optimal seed collection time for *R. brevis* was determined prior to this present work: October during the first week of hot weather (Western Botanical 2012).
- Population genetic structure was assessed and recommendations provided for provenance sourcing of material: geographic locations (i.e. Windarling, Johnston and Perrinvale) to be kept separate (BGPA 2011).
- Preliminary assessment of other seed-based factors provided valuable baseline information to build upon: Western Botanical (seed storage, seed assessment, germination) and Cliffs (seed delivery to site) (Landcare Services 2010; Cliffs 2011, 2012).

Seed quality

OBJECTIVE Assess seed purity and viability following collection and cleaning

Previously collected seed collections (twelve accessions from 2004 - 2009) were sent to BGPA for assessment in early 2013. All subsequent collections for this research program (2013 - 2017) were assessed with the same methods.

After the removal of non-seed material (now pure seed), three methods were used to assess seed quality. Seeds were:

1. Exposed to x-ray assessment (Faxitron Seed Imaging System) and scored depending on the presence of endosperm and an embryo (seed fill).
2. Filled seeds exposed to tetrazolium (1% 2,3,5-triphenyltetrazolium) and scored as viable if a red stain developed (metabolically active).
3. Exposed to two standard germination treatments at 20°C (germination capacity) which were:
    a) water (control)
    b) smoke water (10% v/v)

Ricinocarpos brevis seeds are on average 2.24g (±0.05) in weight and 5.64mm (±0.53) long. Seed fill and germination capacity significantly varied among collections for *R. brevis*. Collections years ranged from 2004 to 2009 and seed fill ranged from 40 to 90%. Germination capacity also varied among collections from 0 to 66%. This indicated that environmental conditions during seed formation shape the quality of the seed produced and this varies from season to season. In addition, the storage history of all the collected (especially the earlier ones) was largely unknown, so poor storage conditions may have contributed to a lesser or greater degree to the poor germination results observed from some of the different seed accessions.

Recommendations for seed quality

- Seed should be collected mature to ensure full development and we recommend passive seed collection with nets or organza bags to catch dehiscing seed as they are naturally released.
- All fresh collections of seed should be cleaned and assessed for seed quality as soon as practical, particularly as *R. brevis* collection quality appears to vary from year to year.
- Seeds that display high fill levels but poor germination should be assessed with tetrazolium to ascertain the levels of metabolic activity.

Germination and dormancy

OBJECTIVE Characterise the seed dormancy and seed germination traits of *R. brevis*

Seed from Accession 6224 (collected in 2008 from the Windarling population (W3)) were used for all subsequent experiments. After BGPA received seed from Cliffs, this collection was stored in the Seed Technology Centre under standard seed storage conditions (15°C and 15% eRH: Equilibrium Relative Humidity) until required. The following methods outline the experiments conducted to assess conditions for germination, techniques to alleviate dormancy, techniques to stimulate germination and estimates of seed aging (e.g. longevity).

Standard assessment conditions for seed dormancy and germination were:

1. Incubation under different **temperature** regimes. Seeds were kept in the dark and were placed on either water (control) or exposed to smoke water (10% v/v) for 24 hours prior to sowing. The temperature regimes assessed were:
    a) seven constant temperature regimes (5, 10 , 15, 20, 25, 30 and 35°C)
    b) three alternating (12 hour cycle) temperature regimes (10/20°C, 15/25°C and 20/35°C) indicative of different seasons (winter, autumn/spring, summer)
    c) cold stratification (8 weeks at 5, 10 or 15°C then 6 weeks at 20°C)
    d) warm stratification (8 weeks at 25, 30 or 35°C then 6 weeks at 20°C)
2. Incubation in the presence or absence of **light** at four different temperatures on water (control) or following exposure to smoke water (10% v/v). Details were as follows:
    a) light was a 12 hour photoperiod (30W cool white fluorescent lamps with a PFFD of 30 µmol/m^2/s^1)
    b) seeds maintained in darkness were double wrapped (alfoil) and only scored after eight weeks continuous darkness
    c) temperatures tested were 10, 15, 20 and 25°C
3. Incubation at different **depth**s involved initially treating seeds with smoke water (10% v/v), sowing in potting mix (one part coarse sand, one part perlite, two parts potting mix) in pots and incubating at 20°C for up to 20 weeks. Fifty seeds were sown per treatment at the following depths:
    a) surface (0)
    b) 1, 2, 3, 4, 5, 6, 7, 8, 11, 13 and 15 cm below the soil surface

Pre-treatment methods used to alleviate seed dormancy involved exposure of seeds to four standard germination stimulants at incubation at 20°C which were:

a) water (control)
b) gibberelic acid (GA_3) at 100ppm
c) karrikinolide (KAR_1) at 100ppb
d) smoke water at 10% v/v

Rapid aging conditions involved:

1. Storing seeds at 45°C and 60% eRH and removing seeds at regular intervals (every few days) to assess germination capacity.

2. Seeds were exposed to smoke water (10% v/v) and germinated under controlled conditions (20°C) as previously described.

Understanding soil seedbank dynamics through seed burial and retrieval experiments involved:

1. Placing seed into porous, nylon bags, placing these sealed bags into protective stainless steel mesh bags that were then buried under 1cm of soil under field conditions.
2. Bags were retrieved at several time intervals (6, 12, 18 and 24 months) and assessed for seed fill using an x-ray machine.
3. Following x-ray assessment, filled seeds were germinated under controlled conditions (20°C) as previously described and treated with:
    a) water (control)
    b) smoke water (10% v/v)

Ricinocarpos brevis appear to have physiological dormancy when fresh, with a greater proportion of dormant seeds found in fresh rather than aged collections. Indeed, germination of fresh seeds was very low (<10%), though pre-treatment of fresh seeds with germination stimulants (gibberelic acid – GA_3, smoke water - SW or karrikinolide – KAR_1) enhanced the germination response of seeds by 20 to 50% under controlled conditions. Germination under controlled conditions occurs within 7 to 14 days and is most rapid at 20°C. *Ricinocarpos brevis* is sensitive to light with a 20% reduction in germination when exposed to regular 12 hour light conditions. *Ricinocarpos brevis* seed was found to be relatively shorter lived because exposure to rapid aging conditions showed that seeds lost their viability quite quickly (50% reduction after only 10 days exposure to rapid aging conditions). The seed burial and retrieval experiments showed that seeds lose viability over time, but that they can remain viable for up to two years in the soil seedbank.

Recommendations for germination and dormancy

- Sow seeds in autumn/winter when rainfall is more reliable (on average) and because optimal germination occurs between 15 to 25°C.
- Seed should be buried when sown in the field, as light suppresses germination.
- Bury seed 1-2cm under the surface of the soil to enhance germination potential.
- Recommend pre-treating seed with gibberellic acid to maximise germination response in fresh seeds.

- Due to the rapid aging of seeds, we recommend seeds be quickly processed and stored at 15°C and 15% relative humidity.
- Recommend monitoring directly seeded plots for multiple seasons (2-3 years) after sowing because seed remains viable in the soil for up to several years.

Seed banking

OBJECTIVE Develop methods for short-term and long-term storage of seed for conservation

Seed was stored under several conditions (described below) and retrieved for assessment of viability and germination capacity after storage for three different time intervals (6 months, 19 months and 35 months) and compared to germination at 0 months, prior to storage.

Four standard storage environments were assessed to determine storage behaviour. Prior to storage seed was dried in a drying room (15°C and 15% eRH) for 12 weeks and then stored under the following conditions:

1. Standard shed (ambient temperature (5-44°C) and exposure to ambient relative humidity) in paper envelopes.
2. Domestic freezer (-18°C) in laminated foil bags.
3. Liquid nitrogen (-196°C) in sealed cryovials.
4. Standard drying room (15°C and 15% eRH) in paper envelopes.

Ricinocarpos brevis appeared to be sensitive to certain storage conditions. Storage at -18°C or ambient temperature (shed conditions) had 0-9% germination capacity after three years. Storage in liquid nitrogen (-196°C) or under standard drying room conditions (15°C and 15% eRH) had 39-55% germination capacity after three years. There was a risk of damage to seed (loss of seed coat; 20% of all seeds) when placed in liquid nitrogen, but this did not appear to impact germination when removed from storage and assessed for germination.

Recommendations for seed banking

- Optimal long-term storage conditions for *R. brevis* seeds is 15°C and 15% eRH (Equilibrium Relative Humidity), which is the current best practice standard for seed banking (MSBP 2015; RIAWA 2015).
- Investigate the mechanisms causing *R. brevis* seeds to perform poorly when stored at -18°C.

Seed enhancement technology

OBJECTIVE Develop seed enhancement techniques to optimise the effectiveness of seed broadcasting to improve the establishment of *R. brevis*

Seed from Accession 6224 (collected in 2008 from the Windarling population (W3)) were used for all seed enhancement experiments. After BGPA received seed from Cliffs, this collection was stored in the Seed Technology Centre under standard storage conditions (15°C and 15% eRH) until required. The following methods outline the experiments conducted to develop seed enhancement techniques to improve seedling establishment under field conditions.

Translocation field trials (2014 - 2017) involved sowing seed into marked areas that were caged to prevent herbivory (Figure 3). Each replicate held 25 seeds and each treatment had four to eight replicates, with the amount used in a single translocation trial totalling 2,200 seed (see Appendix 1 for the experimental design of each translocation trial).

Four **seed priming** methods were trialled over five exposure periods (1, 2, 3, 4 or 5 days) under laboratory conditions. Seeds were soaked in various solutions for different lengths of time, then dried back (15°C and 15% eRH for three weeks) before incubation under controlled conditions (20°C for 10 weeks) to assess germination capacity. The priming solutions consisted of the following:

1. water only (Hydropriming)
2. -0.2 MPa poly-ethylene glycol (PEG 8000) solution (Osmopriming)
3. 100ppm gibberelic acid (GA_3) plus 1µm karrikinolide (KAR_1) solution (Hydropriming)

4. -0.2 MPa poly-ethylene glycol (PEG 8000) with 100ppm gibberelic acid (GA_3) plus 1µm karrikinolide (KAR_1) solution (Osmopriming)

We trialled the two best seed priming treatments under field conditions for four translocations experiments spanning four consecutive years (2014 - 2016). Seeds were prepared as previously described and the following treatments were trialled on waste rock landforms (W2, W3):

1. control (untreated seed)
2. smoke water (10% v/v)
3. 100ppm gibberelic acid plus 1µm karrikinolide solution (hydroprimed for five days)

Under laboratory conditions, hydropriming (water) and osmopriming (poly-ethylene glycol) increased the rate of germination (maximum at six weeks) but not the total number of germinants observed compared to standard germination tests. With the addition of the germination stimulants (GA_3 and KAR_1) to the hydropriming and osmopriming solutions the germination rate was significantly enhanced and an increase in the total number of germinants was observed. The best germination result was obtained when *R. brevis* seeds were hydroprimed with germination stimulants (GA_3 plus KAR_1) over five days.

Under field conditions, seed priming increased the number of seedlings emerging in four of the four translocations experiments undertaken using directly sown seeds (2014-2016). The percentage emergence in the field (1.0 - 9.5%) for primed seeds did not achieve the same germination rates found under laboratory conditions (40 – 70%). However, *R. brevis* seeds had greater seedling emergence when seeds were primed (with either smoke water or hydroprimed with germination stimulants) prior to sowing in the field than seeds that were not primed (i.e. controls used to compare the effects of the various treatments).

A **pelleting** trial was conducted in the 2017 translocation, with primed (as above) and non-primed seed, but the lack of rainfall (52% below average for 2017) meant that no seedlings were observed to emerge and so the effectiveness of the pelleting treatment under field conditions could not be assessed. A complementary trial was conducted in the glasshouse and showed that the technique of pelleting had limited success under glasshouse conditions with no clear treatment effect from the use of the pelleting treatment.

Recommendations for seed enhancement technology and site delivery

- Seed enhancement techniques can be used on large volumes of seed in a short period of time.
- Hydropriming seeds with germination stimulants (GA_3 plus KAR_1) for five days increased the germination capacity, particularly germination rate, of *R. brevis* under controlled glasshouse conditions.
- Under field conditions, we recommend pre-treating seeds with either smoke water (10% v/v) or hydropriming seeds with germination stimulants (GA_3 and KAR_1) for five days, to increase seedling emergence in translocation sites.
- Recommend additional research to confirm if pelleting is a viable option for improving seedling establishment, as field trials were inconclusive.
- Site preparation should involve a layer of topsoil that has been ripped to allow ease of seed burial (seeds sown on berms not slopes).
- Sow seeds in autumn/winter because it allows a greater window of opportunity for rainfall to naturally trigger germination and a longer period of seedling establishment before the onset of the dry summer months (later sowing is likely to decrease the chance of seedling establishment).
- Recommend regular irrigation (~every three days) of seeded plots and germinating seedlings throughout their first year and particularly through their first summer (see Theme 2).

3.3 Tubestock establishment

Background

For species that do not set sufficient seed for direct seeding, or are difficult to germinate in large numbers as often required, plants must be established using vegetative material and the species introduced to site via tubestock planting (Miller *et al.* 2017). The two main avenues of vegetative tubestock development involve traditional tip cutting propagation or more advanced tissue culture methods (maintaining growing plant tissues under optimal culture conditions – controlled nutrient, hormone light and temperature) (Bunn *et al.* 2011).

Standard horticultural propagation

OBJECTIVE
Optimise plant production under *ex situ* conditions in a nursery environment

Propagation material was initially sourced from three plants salvaged from a natural population that were removed due to ongoing mining activity. Once collected, these plants were moved to Kings Park, pruned, potted into standard native potting mix and maintained under standard nursery conditions. Within several months these salvaged plants had begun to reshoot, and shortly thereafter had produced sufficient shoot material to support some small-scale preliminary propagation trials. Additional vegetative propagation material was obtained from 2015 onwards from nursery grown seedlings that had been potted up following the completion of early seed germination trials. This later source of propagation material was used for the majority of the vegetative propagation assessments. Four native plant nurseries were sent vegetative propagation material (shoots) to assess the feasibility of using standard commercial nursery propagation approaches to produce plants for future translocations.

Standard nursery propagation techniques assessed for vegetative cuttings involved determining a suitable:

1. Source of plant material
    a) actively growing softwood shoots
    b) semi-dormant softwood shoots
    c) semi-dormant secondary softwood (below shoot tip)
    d) semi-hardwood shoots
2. Propagation media
    a) standard propagation mix (one part peat, one part perlite, one part sand)
    b) alternative propagation mix (one part peat, one part perlite, two parts sand)
    c) rockwool
    d) aerated peat plugs
    e) potting mix only
    f) white sand only
    g) potting mix and white sand (one part each)
3. Propagation container
    a) standard plastic forestry pots

b) biodegradable pots (Figure 5; Fertil:Greentech; Rice husk:Norwood Industries)

Ricinocarpos brevis was relatively slow to develop roots, establish and grow from cuttings (or seed). Strike rate from cuttings was most successful with actively growing softwood material (~65%). Standard propagation media was the most successful for striking cuttings and for survival after potting on into larger pots. Plants from either seed or cuttings, can be successfully maintained under nursery conditions when provided with larger pots (>15cm diameter), semi-regular pruning (every 12 months), regular fertilising (e.g. Osmocote Native Plant every 6 months), well draining media (native plant potting mix, perlite and/or coarse sand), a sparing watering regime (i.e. water only when soil surface begins to dry out; move plants under cover during wet winter months) and full sun. Plants have been maintained for four years under nursery conditions and have regularly flowered at three to four years of age (a few began flowering after two years). Plants could establish and grow in biodegradable pots (Fertil and Rice husk) under nursery conditions. Plants in Fertil biodegradable pots pushed their roots through pot walls, however, the walls needed to be constantly moist (Figure 5c&d). Both biodegradable pots have proved to be a suitable and alternative method/container for planting tubestock for *in situ* translocations (see “Tubestock establishment in experimental translocations” sub-section below).

Recommendations for standard horticultural propagation

- The source of propagation material for cuttings should be healthy, actively growing softwood shoots (natural or nursery sources). Recommend natural collections during winter/spring when foliage is actively growing (i.e. supple) as well as applications of native plant fertiliser under nursery conditions to stimulate rapid growth of young softwood shoots.

Recommend a propagation media that is well drained and has a lower proportion of organic matter that is supplemented with perlite or coarse river sand for good drainage and porosity. For striking cuttings and germinating seed, the ideal propagation media was one-part peat, one-part perlite, one-part coarse river sand. For establishing seedlings and maintaining adult plants the ideal potting medium was two-parts organic matter (native plant potting mix or composted jarrah sawdust), one-part perlite and one-part coarse river sand. However, 60% organic matter and 40% perlite was also effective.

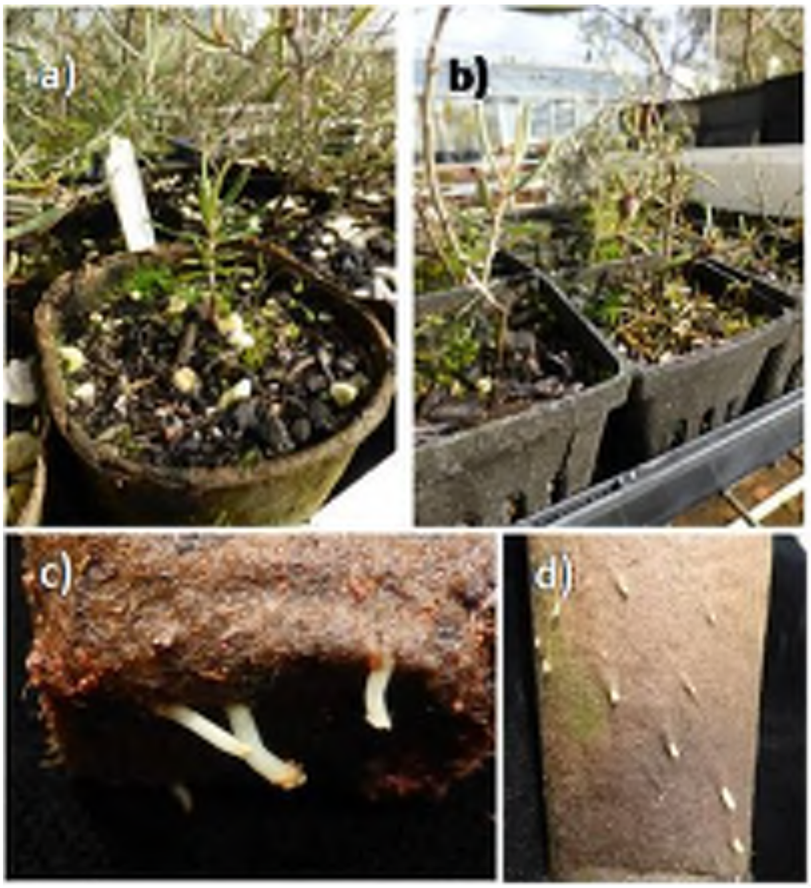


Figure 5. The two biodegradable pots trialled for *in situ* translocations *ex situ* maintenance. a) Fertil pot (large) containing a young *R. brevis* seedling; b) Rice husk pot (small) containing *R. brevis* cuttings; c) *R. brevis* roots emerging from the base of a Fertil pot; and d) *R. brevis* roots emerging from the sides of a Fertil pot.

- Recommend engagement with commercial nurseries early in a translocation program to discuss any specialist propagation and maintenance requirements for the species, to accommodate testing of propagation material by the supplier, and for the supplier to optimise their operations to produce a healthy collection of plants for translocation in sufficient numbers.
- Recommend that the ideal vegetative propagation material be supplied to commercial nurseries up to 12 months before plants are needed for translocations *in situ*.
- For cuttings, recommend ten weeks incubation in a propagation glasshouse (hourly misting of water and 20-25°C ambient temperature) on **heated sand beds** (~25°C) before transfer into the above described adult plant native potting mix.
- For seedlings, recommend a relatively dry environment, in a well-ventilated location, preferably on a **heated mats** (~25°C) to enhance root development under nursery

conditions, until root ball fills pot/cell before transfer to larger pots containing well drained potting mix (described above).

- Sown seeds should be kept moist for germination, however due to sensitivity to fungal attack under nursery conditions, we recommend that establishing seedlings and maintenance of adult plants have the following conditions, for a greater chance of survival:
    - a larger pot
    - full sun location
    - a **watering regime** that uses water sparingly (i.e. water only when soil surface begins to dry out. Approximately once a week during winter and three times a week during summer, but more frequently if pots are less than 15cm diameter)
    - regular fertiliser (Osmocote and/or FetrilonCombi2)
    - semi-regular pruning (once a year or every two years)
- We recommend the use of standard plastic pots for maintaining *ex situ* collections and tubestock under nursery conditions, however, tubestock needs to be 8-18 months old to be of a sufficient size and maturity for translocation.
- *R. brevis* will grow in biodegradable pots (Fertil and Rice husk) and under *ex situ* conditions, can push roots through the pot walls or slits, however, they should not be used for long-term (>12 months) *ex situ* maintenance

Specialised propagation technology

OBJECTIVE Optimise plant production under *ex situ* conditions in a laboratory environment

The use of more advanced propagation techniques can be advantageous under some circumstances, such as with plant susceptibility to root disease, low success from seed propagation, only a few remaining wild plants or low success from cutting propagation. However, while effective, these types of propagation approaches can be considerably more expensive and time consuming. To assess the feasibility of these types of approaches on *R. brevis* an initial assessment of grafting and plant tissue culture was undertaken using harvested vegetative material from one of the three salvaged plants that was brought back to Kings Park.

The advanced propagation techniques assessed as part of this feasibility study involved:

1. Grafting *R. brevis* onto commercially available *R. tuberculatus* root stock.
2. Plant tissue culture using the following starter material to initiate cultures:
    a) softwood shoots
    b) seeds

Initial grafting assessment was not successful across the 20 plants tested (*R. brevis* grafted onto *R. tuberculatus*). Regeneration of shoot material in tissue culture, while successful using standard tissue culture approaches, also proved to be very slow, with seed material proving to be more successful under tissue culture techniques. Establishing *in vitro* cultures from seed was successful in producing shoots, but whether this material can be multiplied in larger numbers and re-established in soil is unknown as this was not assessed during this preliminary study.

Recommendations for specialised propagation technology

- The **source** of propagation material for tissue culture initiation ideally should be healthy actively growing softwood shoots (natural or nursery sources). Recommend natural collections during winter/spring when foliage is actively growing and applications of native plant fertiliser under nursery conditions to stimulate rapid growth of young softwood shoots.
- We do not recommend grafting as a specialised alternative for establishing a larger number of semi-mature *R. brevis* plants as an *ex situ* containerised collection at this stage.
- If tissue culture is required in future conservation and plant production purposes, we recommend tissue culture initiated with seeds. It will be a potentially expensive option and further research regarding optimal multiplication techniques and successful transfer of plant material to soil is required.

Tubestock establishment in experimental translocations

OBJECTIVE
Develop translocation approaches to optimise the effectiveness of tubestock planting to improve the establishment of *R. brevis*

Seed from Accession 6224 (collected in 2008 from the Windarling population (W3)) were used for all subsequent experiments. Tubestock was derived from seedlings grown from this seed accession or from cuttings of plants grown from this seed accession. The following method outlines the experiments conducted to improve tubestock growth and establishment under field conditions.

Translocation field trials (2014 - 2017) involved planting tubestock into marked areas that were caged to prevent herbivory (Figure 3). Each treatment (see Section 2.2 for the site amendment treatments tested) within the translocation had 10-12 tubestock plants as replicates, with the number used in a single translocation trial totalling 96 plants (see Appendix 1 for the experimental design of each translocation trial).

Optimising tubestock establishment involved trialling the following treatments in the field:

1. Age of the tubestock
    a) younger plants (~6 months old)
    b) older plants (8-18 months old)
2. Source material of the tubestock
    a) grown from seed
    b) grown from cuttings
3. Propagation container
    a) plastic pots
    b) two biodegradable pots (Fertil: Greentech and Rice husk: Norwood Industries)
4. Timing of planting
    a) mid autumn (April)
    b) early winter (June)

Under field conditions, the establishment and survival of tubestock could be improved through certain propagation techniques. Older tubestock (8-18 months; translocations 2015-2017) had greater survival than younger tubestock (6 months; translocation 2014), due to the maturity of roots allowing easier removal of plants from pots (i.e. less root disturbance). Tubestock grown from seed put on more biomass (increased growth) and had greater survival (non-irrigated treatment) than tubestock sourced from cuttings (translocation 2016). Tubestock planted in large or small biodegradable pots had a similar (non-significant) response as the equivalent sized plastic pot when non-irrigated (translocation 2017; Figure 6). Tubestock planted in large biodegradable pots had similar survival to large plastic pots when under irrigation, but small biodegradable pots had greater survival than small plastic pots under irrigation (translocation 2017; Figure 6). Greater survival of tubestock was observed when plants were planted in mid-autumn (translocations 2015-2017) than those planted in early winter (translocation 2014). All tubestock that was shaded and/or irrigated performed better than tubestock that did not have these treatments (translocations 2015-2017).

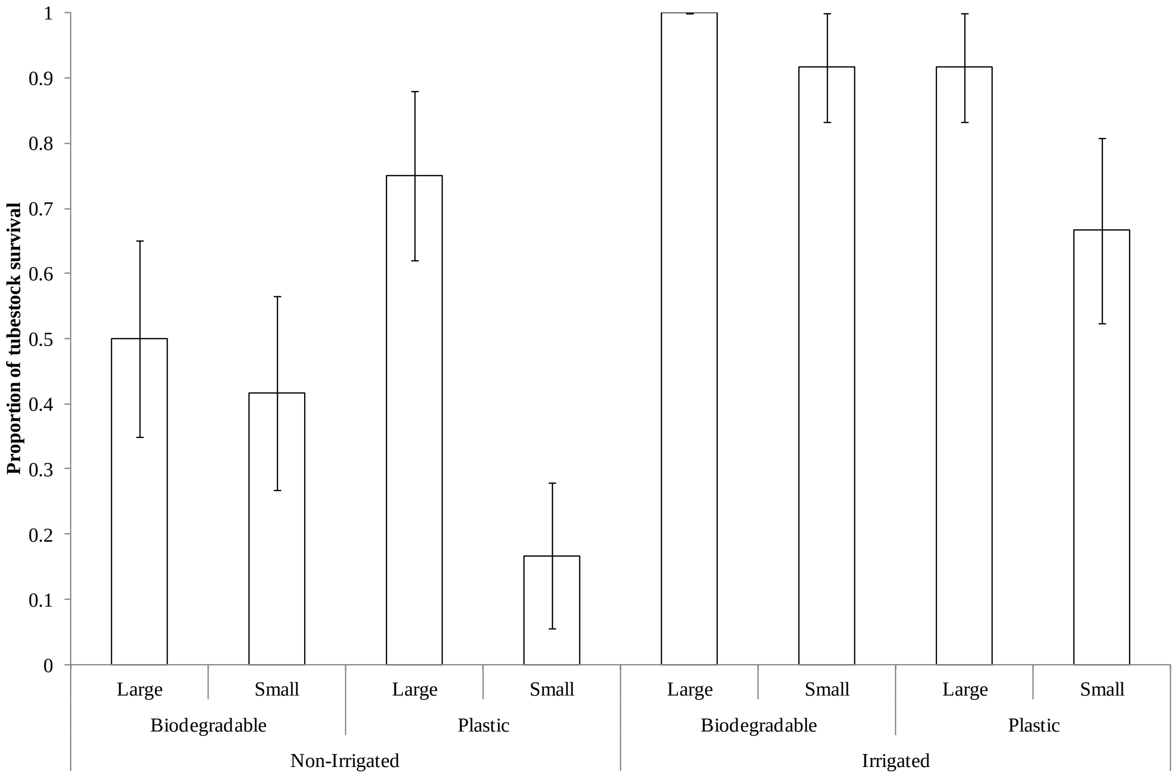
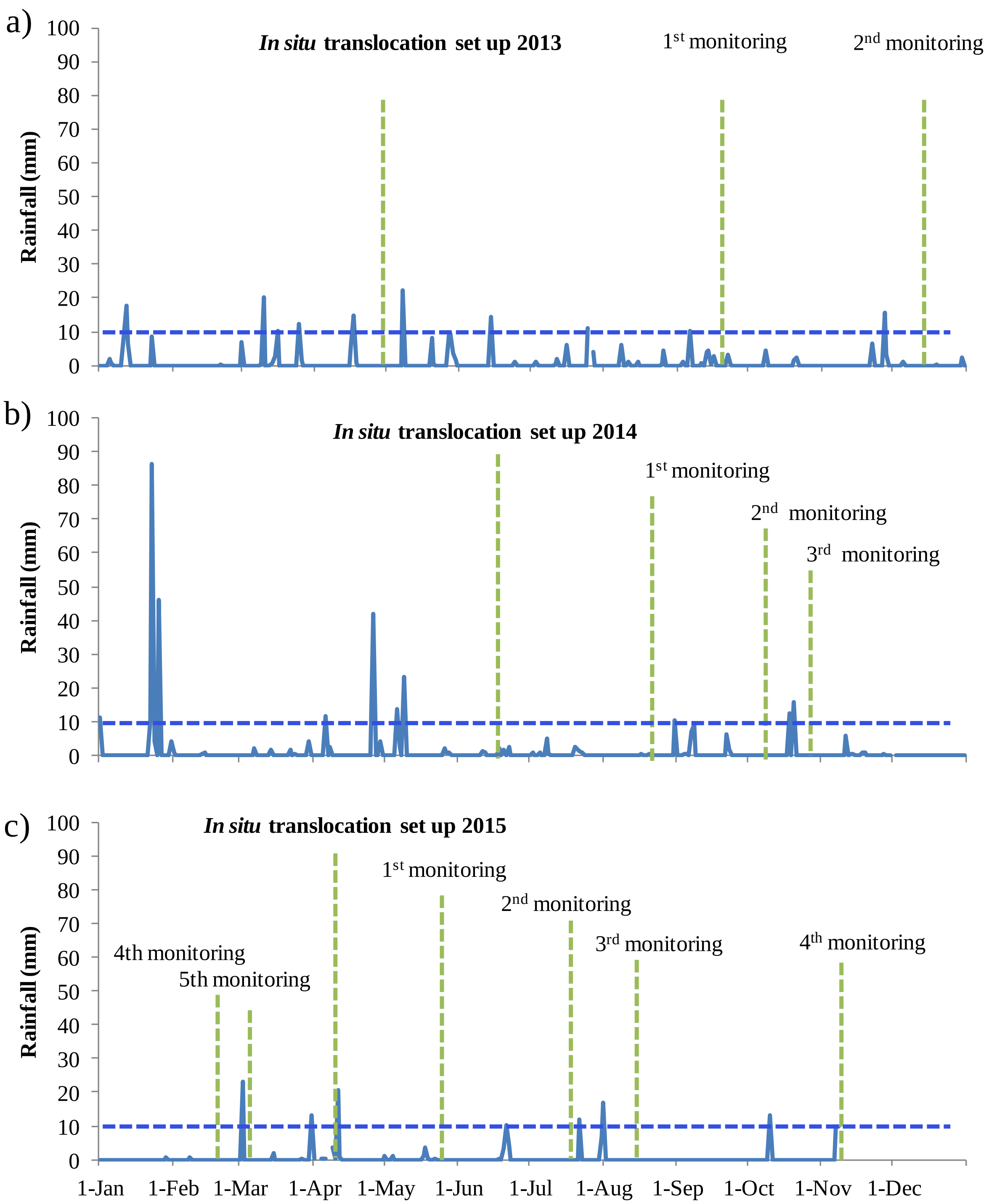


Figure 6: Proportion of tubestock survival after eight months when planted from plastic pots (large and small) or planted in biodegradable pots (large = Fertil and small = Rice husk), also testing the effect of irrigation. Standard error bars.

Overall, the emergence, growth, health and survival of translocated *R. brevis* varied for each translocation year because different treatments were being tested in any one year and seasonal rainfall varied in amount and intensity every year (Figure 7). Table 2 shows the total survival of seedlings and tubestock for each translocation, summarises the rainfall for the year and lists the different treatments tested each year that translocations were undertaken.

Table 2: Summary of the total survival of seedlings and tubestock after 12 months *in situ* since time of sowing/planting. Rainfall is the percentage of rainfall above or below the annual average for Windarling during autumn and winter (March to August). Number of rainfall events that were greater than 10ml or greater than 15ml, during autumn and winter. The time of the year when the translocation trial was installed *in situ*. Listed are the treatments tested for direct seeding and tubestock planting for each year's translocation.

Translocation	**2014**	**2015**	**2016**	**2017**
Rainfall (Mar-Aug)	23% below average	36% below average	4% above average	60% below average
No. events >10ml	five events	six events	six events	one event
No. events >15ml	one event	three events	-	-
Time set up	Early winter	Mid autumn	Mid autumn	Mid autumn
SEED	Burial depth Smoke water Hydropriming Shadecloth Irrigation (once week)	Burial depth Smoke water Hydropriming Shadecloth Irrigation (every 3 days)	Smoke water Hydropriming Water holding crystals Irrigation (every 3 days)	Smoke water Hydropriming Pelleting Irrigation (every 3 days)
Emergence	0 - 7.5%	0 - 8.5%	0 - 9.5%	0
Survival 12 months	0 - 4.5%	0 - 8.5%	0 - 8.0%	-
Survival end 2017	0 - 4.5%	0 - 8.5%	-	-
TUBESTOCK	Shadecloth Fertiliser	Shadecloth Fertiliser Irrigation (every 3 days)	Propagation material Water holding crystals Irrigation (every 3 days)	Biodegradable pot Irrigation (every 3 days)
Survival 12 months	0 - 4.2%	97%	80%	68%
Survival end 2017	0 - 4.2%	95%	-	-


a)
In situ translocation set up 2013
1st monitoring
2nd monitoring
Rainfall (mm)
b)
In situ translocation set up 2014
1st monitoring
2nd monitoring
3rd monitoring
Rainfall (mm)
c)
In situ translocation set up 2015
1st monitoring
2nd monitoring
3rd monitoring
4th monitoring
4th monitoring
5th monitoring
Rainfall (mm)
1-Jan 1-Feb 1-Mar 1-Apr 1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec

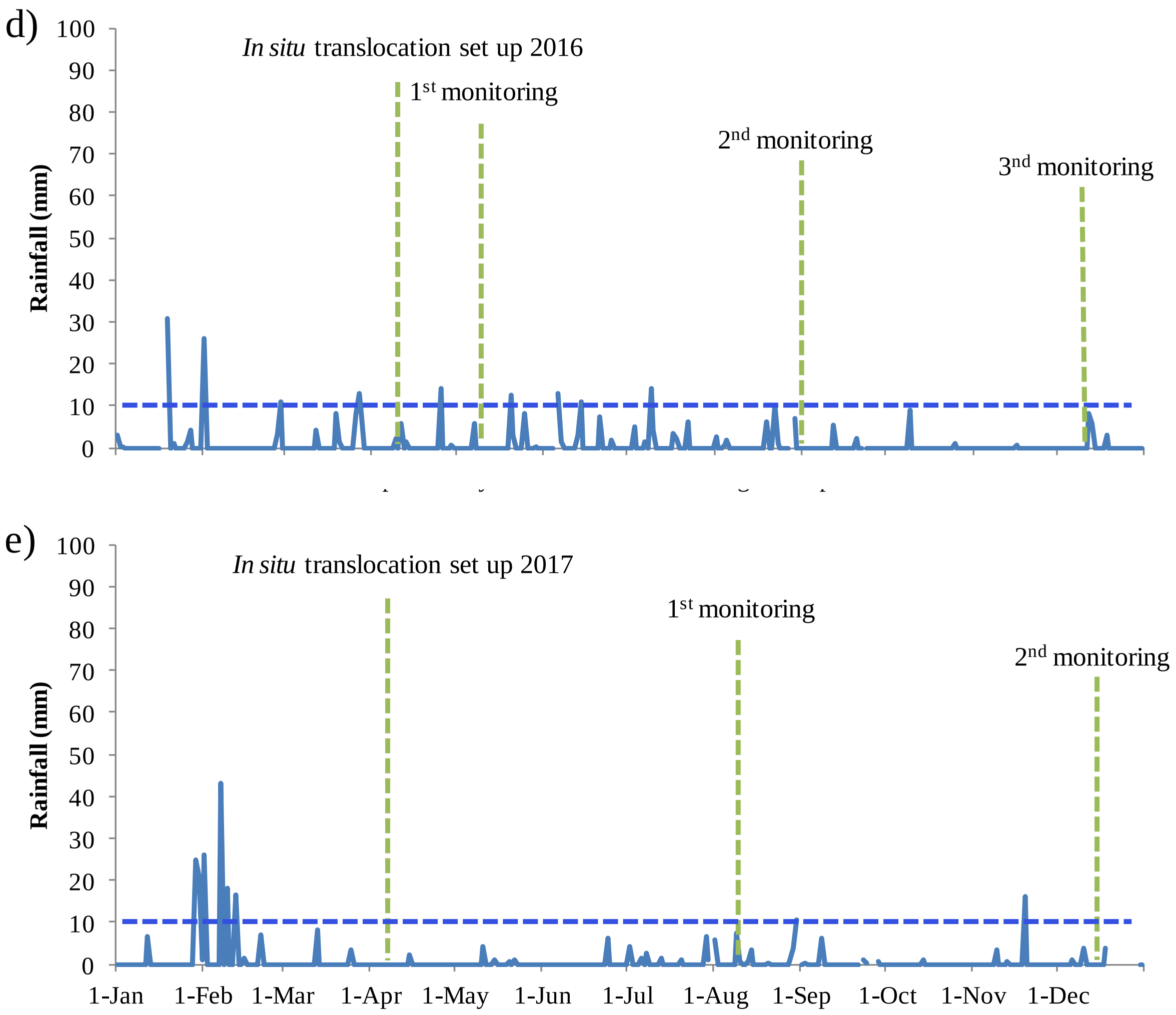


Figure 7: Timing of each translocation set up and monitoring of the translocations for each year (2014 – 2017; green dotted line). Daily rainfall (mm) recorded at Windarling for a) 1 January – 31 December 2014; b) 1 January – 31 December 2015; c) 1 January - 12 September 2016; and d) 1 January – 31 December 2017. Blue dotted line represents 10ml of rainfall.

Overall recommendations for *in situ* tubestock establishment

- See Section 3.2 for recommendations for *in situ* direct seeding.
- Recommend tubestock to be older (8-18 months) for translocation to minimise root disturbance during planting because roots are more mature and resilient.
- Tubestock material sourced from seed performed better (growth, survival) than those sourced from cuttings.

- Recommend the use of biodegradable pots to minimise root disturbance, especially for smaller sized tubestock. The use of these pots is preferential under irrigation (or above average rainfall years).
- Recommend planting tubestock earlier in the season at the first break of rains (mid-autumn) for greatest window for growth and survival before summer.
- Recommend implementation of site amendments to improve establishment of tubestock under field conditions (see Section 2.2).

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Cliffs Asia Pacific Iron Ore

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Appendix 1 – *Ricinocarpos brevis* translocation designs

Experimental design of each translocation trial and year of implementation:

Translocation 2014

- Direct seeding trial
- Tubestock trial

Translocation 2015

- Direct seeding trial
- Tubestock trial

Translocation 2016

- Direct seeding trial
- Tubestock trial

Translocation 2017

- Direct seeding trial
- Tubestock trial

*Translocation proposals written and revised by Cliffs and BGPA were submitted and approved by DPaW prior to implementation of translocations. Copies reside with Cliffs Asia Pacific Iron Ore.

2014 DIRECT SEEDING TRANSLOCATION

Summary of treatments used in the design

- Below are the 11 treatments assessed – all fenced (wire) and but not shaded
- Total number of seeds required: 2,200
- 8 terraces each 11m long
- BLUE SHADING shows the treatments that were irrigated

TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4	TREATMENT 5	TREATMENT 6	TREATMENT 7	TREATMENT 8	TREATMENT 9	TREATMENT 10	TREATMENT 11
Surface sown	Surface sown Smoke water	Buried	Buried Smoke water	Shade cloth Buried Smoke water	Shade cloth Buried Priming	Buried Priming	Buried Smoke water	Shade cloth Buried Smoke water Watering	Buried Priming Watering	Shade cloth Buried Priming Watering

TREATMENT	REPLICATES
NON-IRRIGATED Surface sown	8
NON-IRRIGATED Buried	8
NON-IRRIGATED Surface sown SMOKE	8
NON-IRRIGATED Buried SMOKE	8
NON-IRRIGATED Buried PRIMING	8
NON-IRRIGATED SHADE Buried SMOKE	8
NON-IRRIGATED SHADE Buried PRIMING	8
IRRIGATED Buried SMOKE	8
IRRIGATED Buried PRIMING	8
IRRIGATED SHADE Buried SMOKE	8
IRRIGATED SHADE Buried PRIMING	8

Onsite experimental design (South facing – W2 waste rock landform) for direct seeding translocation

Top of landform

Terrace 8

Surface sown Control 78	Surface sown Smoke water 79	Buried Control 80	Buried Smoke water 81	Shade cloth Buried Smoke water 82	Shade cloth Buried Priming 83	Buried Priming 84	Buried Smoke water 85	Shade cloth Buried Smoke water 86	Buried Priming 87	Shade cloth Buried Priming 88

Terrace 7

Buried Smoke water 67	Shade cloth Buried Smoke water 68	Buried Priming 69	Shade cloth Buried Priming 70	Surface sown Control 71	Surface sown Smoke water 72	Buried Control 73	Buried Smoke water 74	Shade cloth Buried Smoke water 75	Shade cloth Buried Priming 76	Buried Priming 77

Terrace 6

Buried Smoke water 56	Shade cloth Buried Smoke water 57	Shade cloth Buried Priming 58	Buried Priming 59	Surface sown Control 60	Surface sown Smoke water 61	Buried Control 62	Buried Priming 63	Shade cloth Buried Priming 64	Buried Smoke water 65	Shade cloth Buried Smoke water 66

Terrace 5

Buried Priming 45	Shade cloth Buried Priming 46	Buried Smoke water 47	Shade cloth Buried Smoke water 48	Buried Smoke water 49	Shade cloth Buried Smoke water 50	Shade cloth Buried Priming 51	Buried Priming 52	Surface sown Control 53	Surface sown Smoke water 54	Buried Control 55

Terrace 4

Buried Control 34	Surface sown Smoke water 35	Surface sown Control 36	Buried Priming 37	Shade cloth Buried Priming 38	Shade cloth Buried Smoke water 39	Buried Smoke water 40	Shade cloth Buried Smoke water 41	Buried Smoke water 42	Shade cloth Buried Priming 43	Buried Priming 44

Terrace 3

Shade cloth Buried Priming 23	Buried Priming 24	Shade cloth Buried Smoke water 25	Buried Smoke water 26	Buried Smoke water 27	Buried Control 28	Surface sown Smoke water 29	Surface sown Control 30	Buried Priming 31	Shade cloth Buried Priming 32	Shade cloth Buried Smoke water 33

Terrace 2

Buried Priming 12	Shade cloth Buried Priming 13	Shade cloth Buried Smoke water 14	Buried Smoke water 15	Buried Control 16	Surface sown Smoke water 17	Surface sown Control 18	Shade cloth Buried Priming 19	Buried Priming 20	Shade cloth Buried Smoke water 21	Buried Smoke water 22

Terrace 1

Shade cloth Buried Priming 1	Buried Priming 2	Shade cloth Buried Smoke water 3	Buried Smoke water 4	Buried Priming 5	Shade cloth Buried Priming 6	Shade cloth Buried Smoke water 7	Buried Smoke water 8	Buried Control 9	Surface sown Smoke water 10	Surface sown Control 11

Bottom of landform

2014 TUBESTOCK TRANSLOCATION

Summary of treatments used in the design

- Below are the 8 treatments assessed – all fenced (wire)
- Total number of plants required: 96
- 4 terraces each 24m long
- BLUE SHADING shows the treatments that were irrigated

TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4	TREATMENT 5	TREATMENT 6	TREATMENT 7	TREATMENT 8
Shade	Shade Fertiliser	Control	Fertiliser	Shade	Shade Fertiliser	Control	Fertiliser

TREATMENT	REPLICATE
WIRE SHADE	12
WIRE SHADE NON-IRRIGATED	12
WIRE SHADE IRRIGATED Fertiliser	12
WIRE SHADE NON-IRRIGATED Fertiliser	12
WIRE NO-SHADE	12
WIRE NO-SHADE NON-IRRIGATED	12
WIRE NO-SHADE Fertiliser	12
WIRE NO-SHADE NON-IRRIGATED Fertiliser	12

Onsite experimental design (South facing - W2 waste rock landform) for tubestock translocation

Top of landform

Terrace 4

173	Shade 174	Fert. 175	Shade Fert. 176	177	Shade 178	Fert. 179	Shade Fert. 180	181	Shade 182	Fert. 183	Shade Fert. 184	185	Shade 186	Fert. 187	Shade Fert. 188	189	Shade 190	Fert. 191	Shade Fert. 192	193	Shade 194	Fert. 195	Shade Fert. 196

Terrace 3

Shade 149	Fert. 150	Shade Fert. 151	152	Shade 153	Fert. 154	Shade Fert. 155	156	Shade 157	Fert. 158	Shade Fert. 159	160	Shade 161	Fert. 162	Shade Fert. 163	164	Shade 165	Fert. 166	Shade Fert. 167	168	Shade 169	Fert. 170	Shade Fert. 171	172

Terrace 2

Fert. 125	Shade Fert. 126	127	Shade 128	Fert. 129	Shade Fert. 130	131	Shade 132	Fert. 133	Shade Fert. 134	135	Shade 136	Fert. 137	Shade Fert. 138	139	Shade 140	Fert. 141	Shade Fert. 142	143	Shade 144	Fert. 145	Shade Fert. 146	147	Shade 148

Terrace 1

Shade Fert. 101	102	Shade 103	Fert. 104	Shade Fert. 105	106	Shade 107	Fert. 108	Shade Fert. 109	110	Shade 111	Fert. 112	Shade Fert. 113	114	Shade 115	Fert. 116	Shade Fert. 117	118	Shade 119	Fert. 120	Shade Fert. 121	122	Shade 123	Fert. 124

Bottom of landform

2015 DIRECT SEEDING TRANSLOCATION

Summary of treatments used in the design

- Below are the 11 treatments assessed – all fenced (wire) and but not shaded
- Total number of seeds required: 2,200
- 8 terraces each 11m long
- BLUE SHADING shows the treatments that were irrigated

TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4	TREATMENT 5	TREATMENT 6	TREATMENT 7	TREATMENT 8	TREATMENT 9	TREATMENT 10	TREATMENT 11
Surface sown	Surface sown Smoke water	Buried	Buried Smoke water	Shade cloth Buried Smoke water	Shade cloth Buried Priming	Buried Priming	Buried Smoke water	Shade cloth Buried Smoke water Watering	Buried Priming Watering	Shade cloth Buried Priming Watering

TREATMENT	REPLICATES
NON-IRRIGATED Surface sown	8
NON-IRRIGATED Buried	8
NON-IRRIGATED Surface sown SMOKE	8
NON-IRRIGATED Buried SMOKE	8
NON-IRRIGATED Buried PRIMING	8
NON-IRRIGATED SHADE Buried SMOKE	8
NON-IRRIGATED SHADE Buried PRIMING	8
IRRIGATED Buried SMOKE	8
IRRIGATED Buried PRIMING	8
IRRIGATED SHADE Buried SMOKE	8
IRRIGATED SHADE Buried PRIMING	8

Onsite experimental design (South facing – W3 waste rock landform) for direct seeding translocation

Top of landform

Terrace 8

Surface sown Control 78	Surface sown Smoke water 79	Buried Control 80	Buried Smoke water 81	Shade cloth Buried Smoke water 82	Shade cloth Buried Priming 83	Buried Priming 84	Buried Smoke water 85	Shade cloth Buried Smoke water 86	Buried Priming 87	Shade cloth Buried Priming 88

Terrace 7

Buried Smoke water 67	Shade cloth Buried Smoke water 68	Buried Priming 69	Shade cloth Buried Priming 70	Surface sown Control 71	Surface sown Smoke water 72	Buried Control 73	Buried Smoke water 74	Shade cloth Buried Smoke water 75	Shade cloth Buried Priming 76	Buried Priming 77

Terrace 6

Buried Smoke water 56	Shade cloth Buried Smoke water 57	Shade cloth Buried Priming 58	Buried Priming 59	Surface sown Control 60	Surface sown Smoke water 61	Buried Control 62	Buried Priming 63	Shade cloth Buried Priming 64	Buried Smoke water 65	Shade cloth Buried Smoke water 66

Terrace 5

Buried Priming 45	Shade cloth Buried Priming 46	Buried Smoke water 47	Shade cloth Buried Smoke water 48	Buried Smoke water 49	Shade cloth Buried Smoke water 50	Shade cloth Buried Priming 51	Buried Priming 52	Surface sown Control 53	Surface sown Smoke water 54	Buried Control 55

Terrace 4

Buried Control 34	Surface sown Smoke water 35	Surface sown Control 36	Buried Priming 37	Shade cloth Buried Priming 38	Shade cloth Buried Smoke water 39	Buried Smoke water 40	Shade cloth Buried Smoke water 41	Buried Smoke water 42	Shade cloth Buried Priming 43	Buried Priming 44

Terrace 3

Shade cloth Buried Priming 23	Buried Priming 24	Shade cloth Buried Smoke water 25	Buried Smoke water 26	Buried Smoke water 27	Buried Control 28	Surface sown Smoke water 29	Surface sown Control 30	Buried Priming 31	Shade cloth Buried Priming 32	Shade cloth Buried Smoke water 33

Terrace 2

Buried Priming 12	Shade cloth Buried Priming 13	Shade cloth Buried Smoke water 14	Buried Smoke water 15	Buried Control 16	Surface sown Smoke water 17	Surface sown Control 18	Shade cloth Buried Priming 19	Buried Priming 20	Shade cloth Buried Smoke water 21	Buried Smoke water 22

Terrace 1

Shade cloth Buried Priming 1	Buried Priming 2	Shade cloth Buried Smoke water 3	Buried Smoke water 4	Buried Priming 5	Shade cloth Buried Priming 6	Shade cloth Buried Smoke water 7	Buried Smoke water 8	Buried Control 9	Surface sown Smoke water 10	Surface sown Control 11

Bottom of landform

2015 TUBESTOCK TRANSLOCATION

Summary of treatments used in the design

- Below are the 8 treatments assessed – all fenced (wire)
- Total number of plants required: 96
- 4 terraces each 24m long
- BLUE SHADING shows the treatments that were irrigated

TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4	TREATMENT 5	TREATMENT 6	TREATMENT 7	TREATMENT 8
Shade	Shade Fertiliser	Control	Fertiliser	Shade	Shade Fertiliser	Control	Fertiliser

TREATMENT	REPLICATE
WIRE SHADE IRRIGATED	12
WIRE SHADE NON-IRRIGATED	12
WIRE SHADE IRRIGATED Fertiliser	12
WIRE SHADE NON-IRRIGATED Fertiliser	12
WIRE NO-SHADE IRRIGATED	12
WIRE NO-SHADE NON-IRRIGATED	12
WIRE NO-SHADE IRRIGATED Fertiliser	12
WIRE NO-SHADE NON-IRRIGATED Fertiliser	12

Onsite experimental design (South facing – W3 waste rock landform) for tubestock translocation

Top of landform

Terrace 4

	Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.
173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196

Terrace 3

Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.	
149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172

Terrace 2

Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade
125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148

Terrace 1

Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.	Shade Fert.		Shade	Fert.
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124

Bottom of landform

2016 DIRECT SEEDING TRANSLOCATION

Summary of treatments used in the design

- Below are the 10 treatments assessed – all fenced (wire) and but not shaded
- Total number of seeds required: 2,200
- 8 terraces each 11m long
- BLUE SHADING shows the treatments that were irrigated

TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4	TREATMENT 5	TREATMENT 6	TREATMENT 7	TREATMENT 8	TREATMENT 9	TREATMENT 10	TREATMENT 11
Control	Crystal	Smoke water	Priming	Smoke water Crystal	Priming Crystal	SPARE	Smoke water	Priming	Smoke water Crystal	Priming Crystal

TREATMENT	REPLICATES
NON-IRRIGATED CONTROL	9
NON-IRRIGATED CRYSTAL	9
NON-IRRIGATED SMOKE	9
NON-IRRIGATED PRIMING	9
NON-IRRIGATED CRYSTAL SMOKE	10
NON-IRRIGATED CRYSTAL PRIMING	10
IRRIGATED SMOKE	8
IRRIGATED PRIMING	8
IRRIGATED SMOKE CRYSTAL	8
IRRIGATED PRIMING	8

Onsite experimental design (South facing – W3 waste rock landform) for direct seeding translocation

Top of the landform

Terrace 8

Control	Smoke water Crystal	Crystal	Smoke water Crystal	Smoke water	Priming	Priming Crystal	Smoke water	Priming	Smoke water Crystal	Priming Crystal
4078	4079	4080	4081	4082	4083	4084	4085	4086	4087	4088

Terrace 7

Smoke water	Smoke water Crystal	Priming Crystal	Priming	Crystal	Priming Crystal	Control	Smoke water Crystal	Smoke water	Priming Crystal	Priming
4067	4068	4069	4070	4071	4072	4073	4074	4075	4076	4077

Terrace 6

Control	Smoke water Crystal	Priming	Priming Crystal	Crystal	Smoke water	Control	Priming Crystal	Priming	Smoke water	Smoke water Crystal
4056	4057	4058	4059	4060	4061	4062	4063	4064	4065	4066

Terrace 5

Priming Crystal	Smoke water Crystal	Priming	Smoke water	Smoke water	Crystal	Priming	Priming Crystal	Control	Smoke water Crystal	Crystal
45	46	4047	4048	4049	4050	4051	4052	4053	4054	4055

Terrace 4

Control	Smoke water Crystal	Crystal	Priming	Priming Crystal	Smoke water	Smoke water	Smoke water Crystal	Smoke water	Priming	Priming Crystal
4034	4035	4036	4037	4038	4039	4040	4041	4042	4043	4044

Terrace 3

Priming	Priming Crystal	Smoke water Crystal	Smoke water	Priming	Control	Smoke water Crystal	Crystal	Priming Crystal	Priming	Smoke water
4023	4024	4025	4026	4027	4028	4029	4030	4031	4032	4033

Terrace 2

Priming	Priming Crystal	Smoke water Crystal	Smoke water	Control	Priming Crystal	Crystal	Priming Crystal	Priming	Smoke water Crystal	Smoke water
4012	4013	4014	4015	4016	4017	4018	4019	4020	4021	4022

Terrace 1

Priming Crystal	Smoke water Crystal	Priming	Smoke water	Priming Crystal	Priming	Smoke water	Smoke water Crystal	Crystal	Smoke water Crystal	Control
4001	4002	4003	400	4005	4006	4007	4008	4009	4010	4011

Bottom of the landform

2016 TUBESTOCK TRANSLOCATION

Summary of treatments used in the design

- Below are the 8 treatments assessed – all fenced (wire)
- Total number of plants required: 96
- 4 terraces each 24m long
- BLUE SHADING shows the treatments that were irrigated
- GREEN SHADING shows the treatments that were not shaded

TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4	TREATMENT 5	TREATMENT 6	TREATMENT 7	TREATMENT 8
Shade	Shade Water holding crystals	Control	Water holding crystals	Shade	Shade Water holding crystals	Control	Water holding crystals

TREATMENT	CUTTING	SEEDLING
WIRE SHADE IRRIGATED	10	10
WIRE SHADE NON-IRRIGATED	10	10
WIRE SHADE CRYSTAL IRRIGATED	10	10
WIRE SHADE CRYSTAL NON-IRRIGATED	10	10
WIRE NO-SHADE IRRIGATED	2	2
WIRE NO-SHADE NON-IRRIGATED	2	2
WIRE NO-SHADE CRYSTAL IRRIGATED	2	2
WIRE NO-SHADE CRYSTAL NON-IRRIGATED	2	2

Onsite experimental design (South facing – W3 waste rock landform) for tubestock translocation

Top of landform

Terrace 4

Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire
Shade	Shade	Shade	Shade			Crystal	Crystal	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade
		Crystal	Crystal							Crystal	Crystal			Crystal	Crystal			Crystal	Crystal			Crystal	Crystal
SEED	CUTT	SEED	CUTT	SEED	CUTT	SEED	CUTT	CUTT	SEED	SEED	CUTT	CUTT	SEED	CUTT	SEED	SEED	CUTT	CUTT	SEED	CUTT	SEED	SEED	CUTT
4173	4174	4175	4176	4177	4178	4179	4180	4181	4182	4183	4184	4185	4186	4187	4188	4189	4190	4191	4192	4193	4194	4195	4196

Terrace 3

Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire
Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade		Crystal	Crystal		Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade
	Crystal	Crystal			Crystal	Crystal							Crystal	Crystal			Crystal	Crystal			Crystal	Crystal	
SEED	CUTT	SEED	CUTT	SEED	CUTT	SEED	CUTT	CUTT	SEED	CUTT	SEED	SEED	CUTT	SEED	CUTT	CUTT	SEED	CUTT	SEED	CUTT	SEED	CUTT	SEED
4149	4150	4151	4152	4153	4154	4155	4156	4157	4158	4159	4160	4161	4162	4163	4164	4165	4166	4167	4168	4169	4170	4171	4172

Terrace 2

Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire
Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Crystal	Crystal			Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade
Crystal	Crystal			Crystal	Crystal			Crystal	Crystal							Crystal	Crystal			Crystal	Crystal		
SEED	CUTT	CUTT	SEED	CUTT	SEED	SEED	CUTT	CUTT	SEED	SEED	CUTT	SEED	CUTT	SEED	CUTT	SEED	CUTT	CUTT	SEED	SEED	CUTT	CUTT	SEED
4125	4126	4127	4128	4129	4130	4131	4132	4133	4134	4135	4136	4137	4138	4139	4140	4141	4142	4143	4144	4145	4146	4147	4148

Terrace 1

Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire
Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Shade	Crystal			Crystal	Shade	Shade	Shade	Shade
Crystal			Crystal	Crystal			Crystal	Crystal			Crystal	Crystal			Crystal					Crystal			Crystal
CUTT	SEED	CUTT	SEED	SEED	CUTT	SEED	CUTT	CUTT	SEED	CUTT	SEED	SEED	CUTT	SEED	CUTT	SEED	SEED	CUTT	CUTT	SEED	CUTT	SEED	CUTT
4101	4102	4103	4104	4105	4106	4107	4108	4109	4110	4111	4112	4113	4114	4115	4116	4117	4118	4119	4120	4121	4122	4123	4124

Bottom of landform

2017 DIRECT SEEDING TRANSLOCATION

Summary of treatments used in the design

- Below are the 10 treatments assessed – all fenced (wire) and but not shaded
- Total number of seeds required: 1,200
- 8 terraces each 11m long
- BLUE SHADING shows the treatments that were irrigated

TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4	TREATMENT 5	TREATMENT 6	TREATMENT 7	TREATMENT 8	TREATMENT 9	TREATMENT 10	TREATMENT 11
Control	Smoke water	Priming	Smoke Pellet Control	Smoke Pellet Priming	Non-Smoke Pellet Control	Non-Smoke Pellet Priming	Smoke Pellet Control	Smoke Pellet Priming	Non-Smoke Pellet Control	Non-Smoke Pellet Priming

TREATMENT	REPLICATES
NON-IRRIGATED CONTROL	8
NON-IRRIGATED SMOKE	8
NON-IRRIGATED PRIMING	8
NON-IRRIGATED SmokePellet CONTROL	8
NON-IRRIGATED SmokePellet PRIMING	8
NON-IRRIGATED Non-SmokePellet CONTROL	8
NON-IRRIGATED Non-SmokePellet PRIMING	8
IRRIGATED SmokePellet CONTROL	8
IRRIGATED SmokePellet PRIMING	8
IRRIGATED Non-SmokePellet CONTROL	8
IRRIGATED Non-SmokePellet PRIMING	8

Onsite experimental design (South facing – W3 waste rock landform) for direct seeding translocation

Top of landform

Terrace 8

			Smoke pellet	Non-smoke pellet	Non-smoke pellet	Smoke pellet	Non-smoke pellet	Smoke pellet	Non-smoke pellet	Smoke pellet
Control	Smoke water	Priming	Control	Priming	Control	Priming	Priming	Priming	Control	Control
4278	4279	4280	4281	4282	4283	4284	4285	4286	4287	4288

Terrace 7

Smoke pellet	Smoke pellet	Non-smoke pellet	Non-smoke pellet	Non-smoke pellet		Smoke pellet			Smoke pellet	Non-smoke pellet
Priming	Control	Control	Priming	Priming	Control	Priming	Priming	Smoke water	Control	Control
4267	4268	4269	4270	4271	4272	4273	4274	4275	4276	4277

Terrace 6

Smoke pellet	Non-smoke pellet		Non-smoke pellet		Smoke pellet		Smoke pellet	Smoke pellet	Non-smoke pellet	Non-smoke pellet
Priming	Priming	Priming	Control	Control	Control	Smoke water	Control	Priming	Control	Priming
4256	4257	4258	4259	4260	4261	4262	4263	4264	4265	4266

Terrace 5

Smoke pellet	Non-smoke pellet	Non-smoke pellet	Smoke pellet		Smoke pellet		Non-smoke pellet		Non-smoke pellet	Smoke pellet
Control	Priming	Control	Priming	Smoke water	Priming	Priming	Control	Control	Priming	Control
4245	4246	4247	4248	4249	4250	4251	4252	4253	4254	4255

Terrace 4

		Non-smoke pellet	Smoke pellet	Non-smoke pellet		Smoke pellet	Non-smoke pellet	Smoke pellet	Smoke pellet	Non-smoke pellet
Control	Priming	Control	Priming	Priming	Smoke water	Control	Control	Priming	Control	Priming
4234	4235	4236	4237	4238	4239	4240	4241	4242	4243	4244

Terrace 3

Smoke pellet	Non-smoke pellet	Smoke pellet	Non-smoke pellet		Non-smoke pellet	Non-smoke pellet		Smoke pellet		Smoke pellet
Priming	Control	Control	Priming	Smoke water	Priming	Control	Control	Priming	Priming	Control
4223	4224	4225	4226	4227	4228	4229	4230	4231	4232	4233

Terrace 2

	Smoke pellet		Non-smoke pellet		Non-smoke pellet	Smoke pellet	Non-smoke pellet	Smoke pellet	Non-smoke pellet	Smoke pellet
Priming	Control	Smoke water	Priming	Control	Control	Priming	Priming	Control	Control	Priming
4212	4213	4214	4215	4216	4217	4218	4219	4220	4221	4222

Terrace 1

Non-smoke pellet	Non-smoke pellet	Smoke pellet	Smoke pellet	Smoke pellet		Non-smoke pellet		Smoke pellet	Non-smoke pellet	
Priming	Control	Priming	Control	Priming	Priming	Control	Smoke water	Control	Priming	Control
4201	4202	4203	4204	4205	4206	4207	4208	4209	4210	4211

Bottom of landform

2017 TUBESTOCK TRANSLOCATION

Summary of treatments used in the design

- Below are the 8 treatments assessed – all fenced (wire) and shaded
- Total number of plants required: 96
- 4 terraces each 24m long
- BLUE SHADING shows the treatments that were irrigated

TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4	TREATMENT 5	TREATMENT 6	TREATMENT 7	TREATMENT 8
Biodegradable pot Large	Biodegradable pot Small	Plastic pot Large	Plastic pot Small	Biodegradable pot Large	Biodegradable pot Small	Plastic pot Large	Plastic pot Small

TREATMENT	REPLICATE
WIRE SHADE IRRIGATED Large Bio pot (L)	12
WIRE SHADE NON-IRRIGATED Large Bio pot (L)	12
WIRE SHADE IRRIGATED Small Bio pot (S)	12
WIRE SHADE NON-IRRIGATED Small Bio pot (S)	12
WIRE SHADE IRRIGATED Large Plastic pot (L)	12
WIRE SHADE NON-IRRIGATED Large Plastic pot (L)	12
WIRE SHADE IRRIGATED Small Plastic pot (S)	12
WIRE SHADE NON-IRRIGATED Small Plastic pot (S)	12

Onsite experimental design (South facing – W3 waste rock landform) for tubestock translocation

Top of landform

Terrace 4

Wire Shade L PLASTIC 4573	**Wire Shade S BIO 4574**	**Wire Shade S PLASTIC 4575**	**Wire Shade L BIO 4576**	**Wire Shade S PLASTIC 4577**	**Wire Shade L BIO 4578**	**Wire Shade S PLASTIC 4579**	**Wire Shade S BIO 4580**	**Wire Shade S BIO 4581**	**Wire Shade L PLASTIC 4582**	**Wire Shade S PLASTIC 4583**	**Wire Shade L BIO 4584**	**Wire Shade S BIO 4585**	**Wire Shade L PLASTIC 4586**	**Wire Shade L BIO 4587**	**Wire Shade S PLASTIC 4588**	**Wire Shade L PLASTIC 4589**	**Wire Shade S BIO 4590**	**Wire Shade L BIO 4591**	**Wire Shade S PLASTIC 4592**	**Wire Shade S BIO 4593**	**Wire Shade L PLASTIC 4594**	**Wire Shade L PLASTIC 4595**	**Wire Shade L BIO 4596**

Terrace 3

Wire Shade S PLASTIC 4549	**Wire Shade L BIO 4550**	**Wire Shade S PLASTIC 4551**	**Wire Shade L BIO 4552**	**Wire Shade L PLASTIC 4553**	**Wire Shade L BIO 4554**	**Wire Shade S PLASTIC 4555**	**Wire Shade S BIO 4556**	**Wire Shade L BIO 4557**	**Wire Shade L PLASTIC 4558**	**Wire Shade S BIO 4559**	**Wire Shade S PLASTIC 4560**	**Wire Shade L PLASTIC 4561**	**Wire Shade S BIO 4562**	**Wire Shade L PLASTIC 4563**	**Wire Shade L BIO 4564**	**Wire Shade S BIO 4565**	**Wire Shade S PLASTIC 4566**	**Wire Shade L BIO 4567**	**Wire Shade L PLASTIC 4568**	**Wire Shade S BIO 4569**	**Wire Shade L PLASTIC 4570**	**Wire Shade S BIO 4571**	**Wire Shade S PLASTIC 4572**

Terrace 2

Wire Shade S PLASTIC 4525	**Wire Shade L BIO 4526**	**Wire Shade S BIO 4527**	**Wire Shade S PLASTIC 4528**	**Wire Shade S BIO 4529**	**Wire Shade L PLASTIC 4530**	**Wire Shade S PLASTIC 4531**	**Wire Shade L BIO 4532**	**Wire Shade S BIO 4533**	**Wire Shade L PLASTIC 4534**	**Wire Shade S PLASTIC 4535**	**Wire Shade L BIO 4536**	**Wire Shade S PLASTIC 4537**	**Wire Shade S BIO 4538**	**Wire Shade L PLASTIC 4539**	**Wire Shade S BIO 4540**	**Wire Shade L PLASTIC 4541**	**Wire Shade L BIO 4542**	**Wire Shade S BIO 4543**	**Wire Shade L PLASTIC 4544**	**Wire Shade S PLASTIC 4545**	**Wire Shade L BIO 4546**	**Wire Shade L BIO 4547**	**Wire Shade L PLASTIC 4548**

Terrace 1

Wire Shade S BIO 4501	**Wire Shade S PLASTIC 4502**	**Wire Shade S BIO 4503**	**Wire Shade S PLASTIC 4504**	**Wire Shade S PLASTIC 4505**	**Wire Shade S BIO 4506**	**Wire Shade L PLASTIC 4507**	**Wire Shade S BIO 4508**	**Wire Shade S BIO 4509**	**Wire Shade L PLASTIC 4510**	**Wire Shade L BIO 4511**	**Wire Shade S PLASTIC 4512**	**Wire Shade S PLASTIC 4513**	**Wire Shade L BIO 4514**	**Wire Shade L PLASTIC 4515**	**Wire Shade L BIO 4516**	**Wire Shade L PLASTIC 4517**	**Wire Shade L PLASTIC 4518**	**Wire Shade S BIO 4519**	**Wire Shade L BIO 4520**	**Wire Shade L PLASTIC 4521**	**Wire Shade L BIO 4522**	**Wire Shade S PLASTIC 4523**	**Wire Shade L BIO 4524**

Bottom of landform

Appendix 2 – *Ricinocarpos brevis* whole or salvage plant translocation

Cliffs Asia Pacific Iron Ore conducted translocation of whole or salvage plants in 2015, from plants excavated from Windarling Range in 2012. BGPA assisted with survival and reproductive monitoring of translocated plants.

Whole plants were salvaged from natural populations in 2012 and kept in large tree bags with regular irrigation until 26/4/15, when they were translocated to the south side of W2. Plants were watered in and watered once a week until 28/6/15 (two months). Plants were monitored post-planting at 7, 20 and 28 months. The health and reproductive stage of plants were recorded. Several whole plants had accompanying neighbour plants (*R. brevis* or other species) within the tree bag (10) and several were alone (5). There was no obvious effect of neighbours on the survival or health of salvaged *R. brevis* plants, as six plants with neighbours and three plants without neighbours survived after 28 months. In total, nine of the fifteen whole plants were alive after 28 months and five of them were flowering and/or fruiting.

Table A3: Number of whole plants translocated to the south side of W2 (26/4/15) in each category of health score (percentage of the plant that was green and not visually stress), mortality or reproductive stage, at three time points after translocation.

Post-planting	Excellent (>80% green)	Moderate (80-20% green)	Poor (<20% green)	Dead	Flowering or fruiting
7 months	11	1	1	2	2
20 months	7	2	3	3	2
28 months	8	1	0	6	5

- Recommend the salvage of whole plants for future translocations to increase translocation success and genetic diversity, as 60% survival and reproduction were possible two years post-planting.

Appendix 3 – *Ricinocarpos brevis* monitoring updates

Provided to Cliffs Asia Pacific Iron Ore for their stakeholder meetings and reporting requirements:

Cliffs Community Consultation Group

September 2015

September 2016

September 2017

The Annual Environmental Report

December 2016

April 2017

Goldfields Threatened Flora Recovery Team

January 2018

BGPA Update September 2015 for Community Consultation Meeting

Field Trials:

- Germinated seedlings from the 2014 seed broadcast trial on W2 experienced mortality over the summer months (29 seedlings died; not irrigated over the summer), but those that survived the summer are strong and healthy (7 seedlings).
- One survivor from the 2014 tubestock trial on W2 is strong and healthy.
- Established another seed broadcast trial and tubestock trial in April 2015 on W3.
- Tubestock (96 plants) from the 2015 trial are all alive (August 2015).
- Seedlings have emerged from the 2015 seed broadcast trial (38 seedlings), all from the irrigated treatment (i.e. watering every three days; August 2015).

Field Ecology:

- Monitored the reproductive output of Windarling plants (20x) and Johnston plants (20x) for a second year.
- Flowering and seed set are much lower than the previous year at Windarling and plants are not flowering at Johnston. Possibly due to the amount and timing of rainfall events for 2015.
- Two sessions of pollinator observations were conducted on those plants that were flowering at Windarling to identify floral visitors and assess rates of visitation.
- Four insect trapping events have occurred at most sites (ten) in 2015 and the insects are currently being sorted for species identification and the processing for the collection of pollen off them.
- More detailed assessment of population demography at Windarling was carried out by measuring plant sizes (329 plants) along the already established permanent quadrats.

BGPA Update September 2016 for Community Consultation Meeting

Field Trials 2014:

- The 2014 seed broadcast trial on W2, had seven seedlings alive in Sept 2015. One year later, six of these seedlings are still alive and there was new seedling emergence in the trial following the 2016 winter rains (nine new seedlings).
- One survivor from the 2014 tubestock trial on W2 remains alive (strong and healthy).

Field Trials 2015:

- The 2015 seed broadcast trial on W3 had a total seedling emergence of 64 seedlings for the season and 52 seedlings survived the summer, all from the irrigated treatment (i.e. watering every three days). Irrigation to the seed broadcast trial was turned off in April 2016. The 2016 winter rains triggered a new round of seedling emergence, with an additional 118 seedlings emerging in the trial across all treatments (total of 170 seedlings alive).
- 97% of the tubestock from the 2015 trial survived the summer and have put on new growth. Three of these plants produced flowers (1-3 flowers per plant, but no fruit).

Field Trials 2016:

- Established the third seed broadcast trial and tubestock trial in April 2016 on W3.
- The 2016 seed broadcast trial on W3 had seedling emergence of 96 seedlings, across all treatments (including irrigated and seed pre-treatments).
- 93% of the tubestock planted in April (2016) are alive and show signs of recovery from transplantation. The tubestock that died was mainly those produced from cuttings that were not irrigated.

Field Ecology:

- Monitored the reproductive output of Windarling plants (20x) and Johnston plants (20x) for a third consecutive year.
- Flowering and seed set are higher than the previous year (2015) at Windarling and plants flowered at Johnston after not flowering the previous year. Possibly due to the amount and timing of rainfall events for 2016.
- Two sessions of pollinator observations were conducted on those plants that were flowering at Windarling to identify floral visitors and assess rates of visitation.
- Insect trapping was completed at the end of 2015 (7 trapping events at ten sites) and the insects are currently being sorted for species identification and processed for the collection of pollen.
- More detailed assessment of population demography at Windarling was carried out by measuring plant sizes (329 plants) along the already established permanent quadrats.

BGPA Update September 2017 for Community Consultation Meeting

Field Trials 2014:

- The 2014 seed broadcast trial on W2, has nine seedlings alive in Sept 2017.
- One survivor from the 2014 tubestock trial on W2 remains alive (strong and healthy).

Field Trials 2015:

- The 2015 seed broadcast trial on W3 had no new emergence for the season. Seedlings survival dropped to 60% after the 2016/2017 summer (total number surviving: 131 seedlings).
- 97% of the tubestock from the 2015 trial survived two summers (2015/2016 and 2016/2017) and have put on new growth. Two of these plants produced flowers (1-2 flowers per plant, but no fruit). Plants were significantly outgrowing their cages and growth was being compromised, so cages were removed in April 2017, two years after planting.

Field Trials 2016:

- The 2016 seed broadcast trial on W3 had seedling survival drop to 23% after their first summer. All survival seedlings are healthy and putting on new leaves.
- 93% of the tubestock planted in April (2016) are alive and have survived their first summer. Nine of these plants produced flowers (1-2 flowers per plant, but no fruit).

Field Trials 2017:

- Established the third seed broadcast trial and tubestock trial in April 2017 on W3.
- The 2017 seed broadcast trial on W3 had zero seedling emergence across the trial (including irrigated and seed pre-treatments) after four months. This was most likely due to the 85% below average rainfall for the start of the season (April-June).
- 75% of the tubestock planted in April (2017) are alive and show signs of recovery from transplantation. The tubestock that died was mainly those that were not irrigated.

Field Ecology:

- Soil seedbank samples were taken for analysis.

BGPA Update December 2016 for Annual Environmental Report

Field Trials 2014:

- The 2014 seed broadcast trial on W2, had seven seedlings alive in Sept 2015. One year later, six of these seedlings are still alive and there was new seedling emergence in the trial following the 2016 winter rains (nine new seedlings).
- **Pre-summer monitoring recorded the death of the nine new seedlings that emerged this season.**
- One survivor from the 2014 tubestock trial on W2 remains alive (strong and healthy).

Field Trials 2015:

- The 2015 seed broadcast trial on W3 had a total seedling emergence of 64 seedlings for the season and 52 seedlings survived the summer, all from the irrigated treatment (i.e. watering every three days). Irrigation to the seed broadcast trial was turned off in April 2016. The 2016 winter rains triggered a new round of seedling emergence, with an additional 118 seedlings emerging in the trial across all treatments (total of 170 seedlings alive).
- **Pre-summer monitoring saw a 1% decline in the total number of seedlings alive from 170 to 148 seedlings.**
- 97% of the tubestock from the 2015 trial survived the summer and have put on new growth. Three of these plants produced flowers (1-3 flowers per plant, but no fruit).
- **Pre-summer monitoring saw little change in tubestock survival (97%).**

Field Trials 2016:

- Established the third seed broadcast trial and tubestock trial in April 2016 on W3.
- The 2016 seed broadcast trial on W3 had seedling emergence of 96 seedlings, across all treatments (including irrigated and seed pre-treatments).
- **Pre-summer monitoring saw this drop to 74 seedlings, across all treatments.**
- 93% of the tubestock planted in April (2016) are alive and show signs of recovery from transplantation. The tubestock that died was mainly those produced from cuttings that were not irrigated.
- **Pre-summer monitoring saw an additional decline in survival in the non-irrigated treatments taking the proportion of surviving plants to 91%.**

BGPA Update April 2017 for Annual Environmental Report

Field Trials 2014:

- The 2014 seed broadcast trial on W2, had eight seedlings alive in Dec 2016. Following summer, six of these seedlings are still alive and there was new seedling emergence in the trial following the 2016 summer rains (five new seedlings).
- One survivor from the 2014 tubestock trial on W2 remains alive (strong and healthy).

Field Trials 2015:

- The 2015 seed broadcast trial on W3 had 130 seedlings surviving after the second summer (76% survival) with no irrigation.
- 93% of the tubestock from the 2015 trial survived the 2016 summer without irrigation and have put on new growth. One of these plants produced flowers (1-3 flowers, but no fruit).

Field Trials 2016:

- The 2016 seed broadcast trial on W3 had 57 seedlings surviving after their first summer (59% survival), across all treatments (including irrigated and seed pre-treatments).
- 80% of the tubestock planted in April 2016 are alive after 12 months in the field. The tubestock that died was mainly those produced from cuttings that were not irrigated.

BGPA Update January 2018 for the Goldfields Threatened Flora Recovery Team

<u>Field Trials 2014</u>:

- The 2014 seed broadcast trial on W2, had eight seedlings alive in Dec 2017. Following last summer (2016), two of these seedlings died and there were five new seedlings in April 2017. However, the total number of seedlings went from eleven to eight by summer 2017.
- One survivor from the 2014 tubestock trial on W2 remains alive (strong and healthy).

<u>Field Trials 2015</u>:

- The 2015 seed broadcast trial on W3 had 128 seedlings surviving just before the third summer. This equated to 98% survival of seedlings since April 2017 with no irrigation (second year without).
- 95% of the original tubestock from the 2015 trial are still alive and healthy after 33 months in the field. Ten of the plants produced flowers (male and female flowers; one to 100s flowers per plant, but no fruit). Insects were observed visiting the flowers on these plants.

<u>Field Trials 2016</u>:

- The 2016 seed broadcast trial on W3 had 47 seedlings surviving when measured on Dec 2017 (48% survival), which was loss of 10% of the seedlings since April 2016 when irrigation was turned off. Rainfall in 2017 was 52% below average for this period.
- 80% of the tubestock planted in April 2016 are alive after 21 months in the field. The tubestock that died was mainly those produced from cuttings that were not irrigated.

<u>Field Trials 2017</u>:

- The 2017 seed broadcast trial on W3 had no seedlings that had emerged when measured on Dec 2017.
- 68% of the tubestock planted in April 2017 were alive after 9 months in the field. The tubestock that died was mainly those produced from cuttings that were not irrigated. However, six of the plants had flowers (1-20 per plant)
- Rainfall in 2017 was 52% below average for the nine months after the trial was set up.

Appendix 4 – Research communications

PUBLICATIONS

Elliott CP, Wilkinson K and Turner S (2018) Case study: Threatened plant translocation *Ricinocarpos brevis*, Euphorbiaceae. ANPC: Australasian Plant Conservation publication and Guidelines for the Translocation of Threatened Plants publication.

Turner SR, Lewandrowski W, Elliott CP, Merino-Martín L, Miller BP, Stevens JC, Erickson TE, Merritt DJ. 2017. Seed ecology informs restoration approaches for threatened species in water-limited environments: a case study on the short-range Banded Ironstone endemic *Ricinocarpos brevis* (Euphorbiaceae). *Australian Journal of Botany*

INDUSTRY REPORTS

Elliott CP and Turner (2017) 2016 Annual compliance assessment report, Ministerial Statement 982. Appendix 6: Restoration research on *Ricinocarpos brevis*. Botanic Gardens and Parks Authority for Cliffs Asia Pacific Iron Ore.

Elliott CP and Turner (2016) 2015 Annual compliance assessment report, Ministerial Statement 982. Appendix 6: Restoration research on *Ricinocarpos brevis*. Botanic Gardens and Parks Authority for Cliffs Asia Pacific Iron Ore.

Elliott CP and Turner S (2015) 2014 Annual compliance assessment report, Ministerial Statement 982. Appendix 6: Restoration research on *Ricinocarpos brevis*. Botanic Gardens and Parks Authority for Cliffs Asia Pacific Iron Ore.

Turner S and Merino-Martin L (2014) 2013 Annual compliance assessment report, Ministerial Statement 982. Appendix 6: Restoration research on *Ricinocarpos brevis*. Botanic Gardens and Parks Authority for Cliffs Asia Pacific Iron Ore.

Stevens J, Turner S, Miller B and Dixon K (2013/2014) Restoration Research Plan: Yilgarn Operations - Windarling Range. Botanic Gardens and Parks Authority for Cliffs Asia Pacific Iron Ore.

PRESENTATIONS

Elliott CP, Fontaine A, Lewandrowski W, Merritt D, Stevens J, Miller B, Turner S (2017) Application of restoration science to threatened species translocation: Insights from a banded ironstone endemic *Ricinocarpos brevis* (Euphorbiaceae). In *Threatened Species Research Forum, 7-8th September 2017*, Geraldton.

Turner S, Elliott CP, Miller BP, Merritt D (2016) Seed ecology of rare plants. In *Seed traits symposium, 3rd October 2016*, Kings Park.

Turner S, Elliott CP, Fontaine A and Merritt MJ (2016) Seed ecology informs restoration approaches for threatened species in water-limited environments: A case study on the short-range Banded Ironstone endemic *Ricinocarpos brevis* (Euphorbiaceae). In *National Seed Science Forum, 14-18 March 2016*, Sydney.

Miller B, Turner S and Elliott CP (2015) Science for managing, conserving and restoring threatened species. In *Threatened Species Research Forum:* Durack Institute of Technology, *30th October 2015*, Geraldton.

Attachment 18 – Cliffs' ARC Invoices

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TAX INVOICE

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CLIFFS ASIA PACIFIC IRON ORE PTY LTD
LEVEL 11
1 WILLIAM STREET
PERTH WA 6846

Account Number:	CLIFASIA.00
Invoice No:	119225
Date:	18/11/2016

Attention: Vince Roberts

PO Number: KF6981

Description	Net Amount	GST	Total Amount
Attention to: Vince Roberts			
ARC ITTCMR IC150100041 Year 1 contribution	20,000.00	2,000.00	22,000.00
For further information regarding invoice, please contact MS Shuie Liu 08 92661980 or ord-support-sae@curtin.edu.au			
PAYMENT WITHIN 30 DAYS OF INVOICE DATE			
Any expenses, costs or disbursements incurred by the University in recovering any outstanding monies, including debt collection agency fees and solicitor's costs shall be paid by the Customer provided that those costs do not exceed the scale charges as charged by that Debt Collection agency/solicitor. **TOTAL AUD**	**20,000.00**	**2,000.00**	**22,000.00**

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Account Number:	CLIFASIA.00
Invoice No:	119225
Date:	18/11/2016
Amount:[AUD]	22,000.00

Biller Code: **190835**
Ref: **1100001192258**

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CLIFFS ASIA PACIFIC IRON ORE PTY LTD
LEVEL 11
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PERTH WA 6846

Account Number:	CLIFASIA.00
Invoice No:	120521
Date:	14/03/2017

Attention: ACCOUNTS PAYABLE

PO Number: KF7137

Description	Net Amount	GST	Total Amount
Attention to: Vince Roberts			
ARC ITTCMR IC150100041 Year 2 contribution	20,000.00	2,000.00	22,000.00
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Date:	14/03/2017
Amount:[AUD]	22,000.00

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Account Number:	CLIFASIA.00
Invoice No:	121490
Date:	2/06/2017

Attention: Robert Howard

PO Number: KF7137

Description	Net Amount	GST	Total Amount
Attention to: Robert Howard			
ARC ITTCMR IC150100041 Year 3 contribution	20,000.00	2,000.00	22,000.00
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(RES-54576)			
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Account Number:	CLIFASIA.00
Invoice No:	121490
Date:	2/06/2017
Amount:[AUD]	22,000.00

Biller Code: **190835**
Ref: **1100001214904**

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CRICOS Provider Code 00301J

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CLIFFS ASIA PACIFIC IRON ORE PTY LTD
LEVEL 11
1 WILLIAM STREET
PERTH WA 6846

Account Number:	CLIFASIA.00
Invoice No:	122688
Date:	4/09/2017

Attention: Rovert Howard

PO Number: KF7137

Description	Net Amount	GST	Total Amount
Attention to: Robert Howard			
ARC ITTCMR IC150100041 Year 4 contribution	20,000.00	2,000.00	22,000.00
For further information regarding invoice, please contact Shuie Liu 08 92661980 or ord-support-sae@curtin.edu.au (RES-54576)			
PAYMENT WITHIN 30 DAYS OF INVOICE DATE			
Any expenses, costs or disbursements incurred by the University in recovering any outstanding monies, including debt collection agency fees and solicitor's costs shall be paid by the Customer provided that those costs do not exceed the scale charges as charged by that Debt Collection agency/solicitor. **TOTAL AUD**	**20,000.00**	**2,000.00**	**22,000.00**

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Credit Card payments for invoices in AUD accepted online at
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Account Number:	CLIFASIA.00
Invoice No:	122688
Date:	4/09/2017
Amount:[AUD]	22,000.00

Biller Code: **190835**
Ref: **1100001226882**

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1 WILLIAM STREET
PERTH WA 6846

Account Number:	CLIFASIA.00
Invoice No:	123648
Date:	4/12/2017

Attention: Robert Howard

PO Number: KF7137

Description	Net Amount	GST	Total Amount
Attention to: Robert Howard			
ARC ITTCMR IC150100041 Year 5 contribution	20,000.00	2,000.00	22,000.00
For further information regarding invoice, please contact Shuie Liu 08 92661980 or ord-support-sae@curtin.edu.au			
PAYMENT WITHIN 30 DAYS OF INVOICE DATE			
Any expenses, costs or disbursements incurred by the University in recovering any outstanding monies, including debt collection agency fees and solicitor's costs shall be paid by the Customer provided that those costs do not exceed the scale charges as charged by that Debt Collection agency/solicitor. **TOTAL AUD**	**20,000.00**	**2,000.00**	**22,000.00**

Payment Options

Credit Card payments for invoices in AUD accepted online at
https://payments.curtin.edu.au/OneStopWeb/AccountsPayment

Account Number:	CLIFASIA.00
Invoice No:	123648
Date:	4/12/2017
Amount:[AUD]	22,000.00

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Biller Code: 190835
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Attachment 19 – Koolyanobbing Rehabilitation Monitoring Report 2018

Rehabilitation Monitoring Report

Koolyanobbing, Mt Jackson and Windarling Mine Sites.

November 2018

Prepared by
Ecotec (WA) Pty Ltd for

Mineral Resources Ltd
1 Sleat Rd, Applecross, WA 6153
Koolyanobbing Operations.

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

Mineral Resources Ltd (MRL) operates iron ore mines at Koolyanobbing, Mt Jackson and Windarling, having been acquired from Cliffs Asia Pacific Iron Ore during 2018. Mined ore is processed at Koolyanobbing and transported by rail to the Port of Esperance where the processed ore is exported to international customers.

Rehabilitation of waste dumps commenced in 2004. In 2013 a monitoring program was implemented across the operations to enable collection of data from a series of monitoring sites established on rehabilitated waste dumps and in undisturbed vegetation (reference sites). The data collected is intended to demonstrate progress toward, and ultimately achievement of, closure criteria for rehabilitated areas, as agreed by the regulatory agencies.

This report provides the results of monitoring conducted at Koolyanobbing, Mt Jackson and Windarling in November 2018 along with comparison to the reference sites and previously collected data.

2.0 METHODOLOGY

2.1 Monitoring site structure

The monitoring sites were developed while Cliffs operated the project and are based on a layout recommended by Woodman Environmental Consulting. Each transect is 50m x 10m with twenty 2m x 2m quadrats nested within the transect, arranged in five groups of four (Figure 2.1). The corners and centre line of the transect and quadrats are marked with steel "fence droppers".

Transects have been orientated perpendicular to the slope on waste dumps, which was found during the initial trials to provide more diversity than a horizontal alignment.

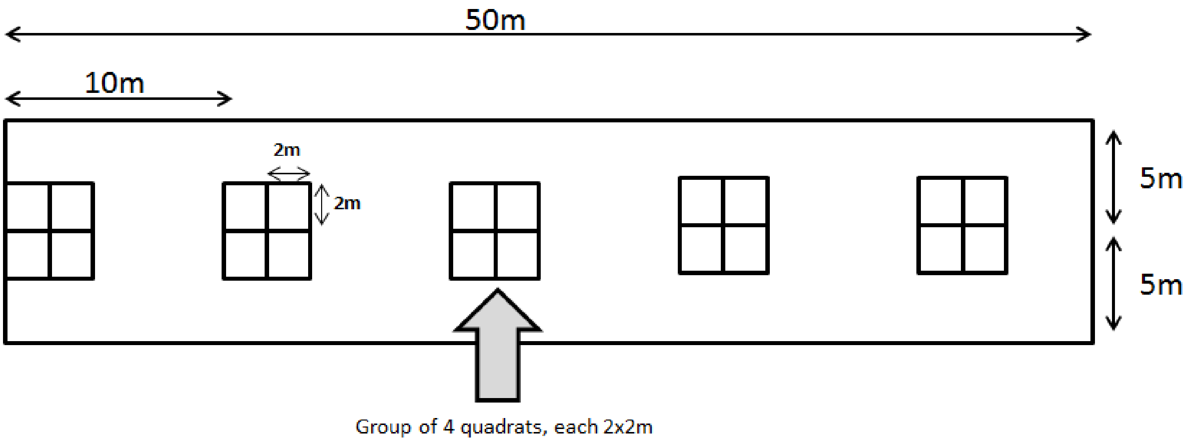


Figure 2.1: Layout of the monitoring sites.

During data collection a photograph is taken from each end of the transect and a tape is laid along the centre line of the transect. Another tape is used to delineate the quadrats.

The information listed in Table 2.1 is then collected. An average for each measured parameter is calculated for the quadrats within the transect. This information is collected for both the reference sites and rehabilitation sites and is used to provide comparative data for assessment of progress toward achievement of closure completion criteria.

Table 2.1: Monitoring observations and parameters

Sampling unit	Observations and Parameters
Transect (50m x 10m)	Photographic record of vegetation from fixed points at the start and end of the plot. Where appropriate, a description of the vegetation unit in accordance with the Native Vegetation Information System (NVIS). Abundance of trees (>1.3m height) and seedlings (<1.3m height) by species (alive and dead). Presence of bare areas greater than 10m x 10m in transect. Description of erosion severity, measured according to a scale that has been developed for the task.
Quadrat (2m x 2m)	% live foliage cover. % dead foliage cover. % leaf litter cover. % exposed rock cover. % bare ground. Species richness for both native and weed species. Abundance of annual and perennial plants by species, alive and dead, for native and weed species.

An assessment of erosion was carried out for each transect using the criteria provided in Table 2.2. The scale is adapted from a Department of Minerals and Energy (c. 1990's) guideline on waste dump rehabilitation.

Table 2.2: Erosion assessment criteria.

Type of Erosion	Rilling/ Sheet/ Gullying/ Dusting/ Piping/ Other		
Severity of erosion	**1**:	Width: <0.2m;	Depth <0.4m
	2:	Width: 0.2m – 0.4m;	Depth 0.4m – 0.8m
	3:	Width: 0.4m – 0.6m;	Depth 0.8m – 1.2m
	4:	Width: 0.6m – 0.8m;	Depth 1.2m – 1.6m
	5:	Width: 0.0m – 1.0m;	Depth 1.6m – 2.0m
	6:	Width: >1.0m;	Depth >2.0m

2.2 Closure completion criteria

Closure completion criteria have previously been defined for the project. Data collected from the rehabilitation sites is used to calculate the criteria, which is then compared to the same data collected from the relevant reference sites.

The criteria are:

- **Average total live foliage cover per 2x2m quadrat** – a measure of the percentage cover of living plants in each quadrat.
- **Average number of live native perennial individuals per 2x2** – a count of the number of living native perennial plants in each quadrat, averaged over the 20 quadrats for each transect.
- **Total native species richness per transect** – the number of species of native plant present within the quadrats of the transect.

2.3 Reference monitoring site locations

Reference monitoring sites have been established in the main vegetation types present in the surrounding area of each waste dump. Three sites have been established per vegetation type and are intended to provide representative data that can be used for comparison with the rehabilitation monitoring sites. The data collected from the monitoring sites within each vegetation type is used to calculate an average for each parameter.

Table 2.2 provides a list of the reference sites that have been established and had data collected to date. Data was collected from the sites shaded in green during the November 2018 monitoring.

Site plans showing the location and vegetation of the reference sites are included in Appendix 1.

Table 2.3: Reference site vegetation types and location.

Koolyanobbing			
Site number	**Vegetation type**	**Coordinate**	
N 01	Salt lake fringing vegetation of *Atriplex* and other Chenopods with occasional shrubs.	740715	6588743
N 02		740526	6588696
N 05		740179	6589001
N 03	*Acacia* shrubland	739928	6590809
N 04		739731	6590805
N 06		739850	6590547
N 07	*Eucalyptus* woodland with occasional shrubs	739465	6590909
N 08		739521	6591069

N 09		739356	6591008
KN 01	Low *Eucalyptus* mallee woodland over tall *Acacia* shrubland	743727	6584421
KN 04		744790	6584214
KN 11		744864	6584993
KN 03	*Eucalyptus* woodland over tall to mid sparse *Atriplex*, *Exocarpa*, *Eremophila* shrubland	744674	6587055
KN 05		742990	6587280
KN 07		743945	6586368
KN 13		743915	6586686
KN 06	Mid to low *Eucalyptus* mallee woodland over tall *Allocasuarina* shrubland	743444	6586288
KN 09		741659	6585880

Mt Jackson			
Site number	**Vegetation type**	**Coordinate**	
JN 01	Closed *Allocasuarina* shrubland	718544	6649904
JN 02		718737	6649432
JN 09		718273	6649712
JN 03	Open *Eucalyptus ebbanoensis* woodland	717668	6649453
JN 04		717477	6649454
JN 13		716636	6649343
JN 05	*Allocasuarina acutivalvis* and *Acacia* sp. Mt Jackson shrubland with occasional Eucalypts	718722	6650756
JN 07		718540	6650688
JN 08		718477	6650526
JN 10	Open *Eucalyptus ebbanoensis* woodland over *Allocasuarina* and *Acacia* sp. Mt Jackson shrubland.	717122	6650758
JN 11		716738	6650179
JN 12		716845	6650124
JN 06	*Acacia effusifolia* and *Allocasuarina acutivalvis* shrubland	718540	6651520
Windarling			
Site number	**Vegetation type**	**Coordinate**	
WN 01	*Eucalyptus longissima* open low woodland over *Acacia effusifolia* and *A. cockertoniana* shrubland	720299	6677348
WN 03		722905	6677210
WN 15		721126	6676458
WN 02	*Acacia effusifolia* shrubland	722717	6676779
WN 11		723001	6676206
WN 12		718476	6678143
WN 04	*Eucalyptus corrugata and E. longissima* woodland over *Acacia effusifolia* and *A. cockertoniana* shrubland	722142	6676399
WN 05		720355	6676100
WN 14		721215	6676480
WN 06	*Acacia aneura* and *A. ramulosa* shrubland.	717491	6676000
WN 07		717620	6678282
WN 08		718782	6678495
WN 09	*Acacia cockertoniana and A. aneura* shrubland with *Olearia humilis*	719217	6678302
WN 10		719013	6678015
WN 13		719228	6678102

2.4 Rehabilitation monitoring site locations

Table 2.3 lists the rehabilitation monitoring sites that have been established and had data collected to date. Monitoring was conducted of those shaded in green during November 2018.

Site plans showing the location of the reference sites are included in Appendix 1.

Table 2.4: Rehabilitation monitoring sites currently established across the project area.

Koolyanobbing							
Site number	**Location**	**Coordinate**		**Site number**	**Location**	**Coordinate**	
K 05	K Waste Dump	740268	6590945	A1 01	A1 Waste Dump	742527	6586576
K 06	K Waste Dump	740382	6591108	A1 02	A1 Waste Dump	743160	6586146
K 07	K Waste Dump	741390	6590938	A1 03	A1 Waste Dump	743050	6585824
K 09	K Waste Dump	740961	6591072	A1 04	A1 Waste Dump	742775	6586453
K 10	K Waste Dump	740399	6591279				
K 11	K Waste Dump	740206	6590281	A2 01	A2 Waste Dump	742448	6587103
K 12	K Waste Dump	740288	6589968				
K 13	K Waste Dump	740647	6589496	BC 01	BC Waste Dump	743891	6586226
K 14	K Waste Dump	740948	6589224	BC 02	BC Waste Dump	744478	6585639
K 15	K Waste Dump	741147	6589256	BC 03	BC Waste Dump	744170	6586025
				BC 04	BC Waste Dump	743483	6585866
Mt Jackson							
J1 01	J1 Waste Dump	707479	6656399	J3 01	J3 Waste Dump	718458	6651366
J1 02	J1 Waste Dump	708066	6656151	J3 02	J3 Waste Dump	718684	6651076
				J3 03	J3 Waste Dump	718516	6650876
J2 01	J2 Waste Dump	716513	6649433				
J2 02	J2 Waste Dump	716461	6649143				
J2 03	J2 Waste Dump	716173	6649715				
Windarling							
W2 01	W2 Waste Dump	717822	6676119	W2 13	W2 Waste Dump	718733	6676460
W2 02	W2 Waste Dump	719153	6676302	W2 14	W2 Waste Dump	718140	6676572
W2 03	W2 Waste Dump	717500	6676876	W2 15	W2 Waste Dump	717843	6676822
W2 04	W2 Waste Dump	718543	6676145	W2 16	W2 Waste Dump	717728	6677145
W2 05	W2 Waste Dump	718877	6676760	W3 01	W3 Waste Dump	720546	6677185
W2 06	W2 Waste Dump	718673	6676581	W3 02	W3 Waste Dump	720822	6677434
W2 07	W2 Waste Dump	719117	6676575	W3 03	W3 Waste Dump	721745	6677606
W2 08	W2 Waste Dump	717530	6677279	W3 04	W3 Waste Dump	721757	6676959
W2 09	W2 Waste Dump	717318	6676570	W3 05	W3 Waste Dump	721952	6677369
W2 10	W2 Waste Dump	718863	6676218	W3 06	W3 Waste Dump	721589	6677194
W2 11	W2 Waste Dump	717577	6676319	W3 07	W3 Waste Dump	721282	6677339
W2 12	W2 Waste Dump	717678	6676556	W3 08	W3 Waste Dump	720896	6677177

2.5 2018 data collection

As per the original intent of the Cliffs monitoring program, data was collected from approximately 1/3 of the rehabilitation and reference sites during the 2018 monitoring. It is intended that the remaining sites will be monitored in subsequent years.

Sites that were not monitored during 2018 were photographed with a vegetation description and health recorded for each. This information is provided in Appendix 2.

3.0 RESULTS

3.1 Overview

Analysis of the data collected during the 2018 monitoring has generally demonstrated very good progress toward achievement of closure criteria across the project. Most of the monitored sites also demonstrated improvement in the closure criteria when compared to previous results. The exception is total species richness, which has decreased across most of the sites, most likely due to the timing of monitoring.

At Koolyanobbing, each of the five sites monitored in 2018 on A1, A2 and B-C waste dumps demonstrated achievement of closure criteria. One of the monitored sites on K Waste Dump demonstrated achievement of closure criteria, two demonstrated partial achievement and one has not achieved any of the criteria at this stage.

At Mt Jackson, each of the monitored sites on the J1, J2 and J3 waste dumps demonstrated at least partial achievement of closure criteria.

At Windarling, each of the three sites monitored on W2 Waste Dump demonstrated achievement of closure criteria, while the three sites on W3 waste dump demonstrated partial achievement.

The following sections provide a summary of the results of monitoring for each site, including tables showing comparison of the rehabilitation data with reference site data for each of the closure criteria. Monitoring site numbers in green are those for which monitoring was conducted in 2018. Those in red were monitored in previous years. The "Comparison to previous" column provides an indication of improvement (↑) or decline (↓) compared to previous monitoring data (where available).

3.2 Koolyanobbing

3.2.1 K Waste Dump

Monitoring was undertaken on K Waste Dump at sites K 06, K 09, K 12 and K 14 on 1 November 2018. Reference sites N 01, N 03 and N 07 were also completed during the 2018 monitoring period and the results combined with the previous data to provide updated comparative data.

Species richness

The number of native species in each of the monitored waste dump transects ranged from 7 to 13. In comparison, the reference sites ranged from 15 to 25 native species per transect.

Abundance

The average number of live native plant individuals per 2 x 2m quadrat in each waste dump transect ranged from 0.5 (K 14) to 26.9 (K 09). The average number of live native plant individuals per 2 x 2m reference site quadrat ranged from 2 to 97.

Weeds

Ward's weed (*Carrichtera annua*) was the only weed species recorded in the waste dump monitoring sites in November 2018. No weeds were recorded in the reference sites.

General comments

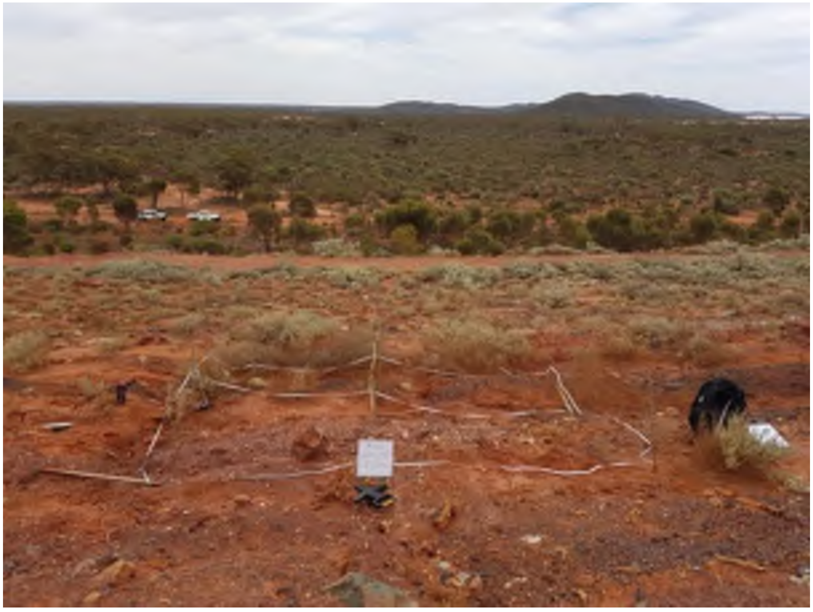
Soils on K Waste Dump are generally moderately to highly saline, often with a salt crust visible on the surface. The southern end of the waste dump is the worst affected, having had extremely saline waste material placed on the outer surface prior to rehabilitation.

The following pages provide a summary of the data collected and photographs from each of the three K Waste Dump rehabilitation monitoring sites completed in November 2018.

Table 3.1 provides a comparison with the closure criteria developed from data obtained from the reference sites.

Site number:	**K 06**
Date:	1/11/2018
Vegetation description:	*Atriplex vesicaria* and *Atriplex codonocarpa* mid open chenopod shrubland over *Maireana tomentosa* low sparse chenopod shrubland over *Mesembryanthemum nodiflorum* low sparse herbland.
Erosion:	Minor rilling throughout transect. Severity = 1-2.
Comments:	Patches of potentially hostile waste rock throughout the transect. Very limited growth in these areas.
Photograph 1:	K 06 North end

Photograph 2: K 06 South end



Site number:	K 09
Date:	1/11/2018
Vegetation description:	*Atriplex vesicaria* and *Atriplex codonocarpa* mid open shrubland over low sparse Chenopod shrubland over *Mesembryanthemum nodiflorum* low sparse herbland.
Erosion:	Minor rilling throughout transect. Severity = 1-2.
Comments:	Salt on the surface at the top of the transect.
Photograph 1:	K 09 North end

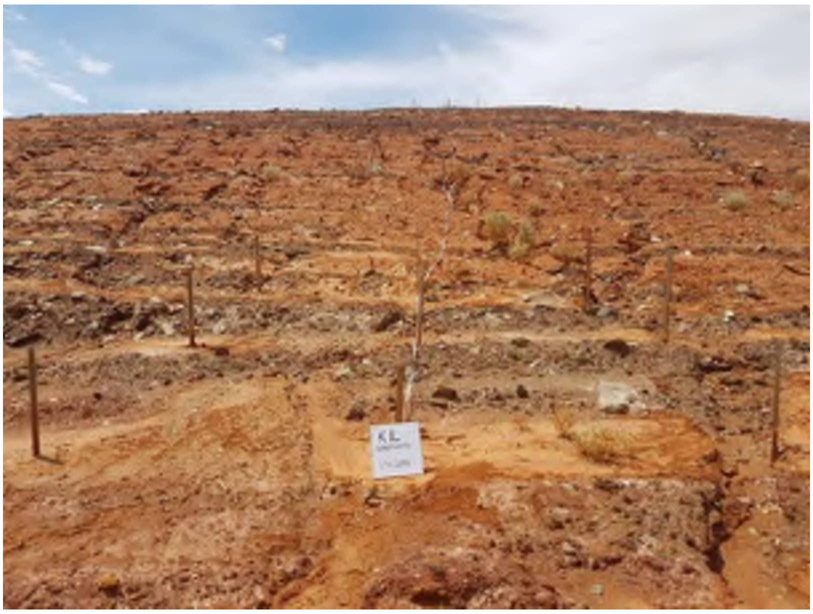
Photograph 2:	K 09 South end

Site number:	K 12
Date:	1/11/2018
Vegetation description:	*Atriplex vesicaria* and *Atriplex codonocarpa* mid open Chenopod shrubland over low sparse Chenopod shrubland.
Erosion:	Minor rilling throughout transect, severity higher at upper end of transect. Severity = 1-2.
Comments:	Slope has been prone to erosion but now appears reasonably stable.
Photograph 1:	K 12 East end

Photograph 2:	K 12 West end

Site number:	**K 14**
Date:	1/11/2018
Vegetation description:	Isolated Chenopod shrubs.
Erosion:	Minor-moderate gully erosion throughout transect. Severity = 2.
Comments:	Extremely saline soils with salt expression evident on the surface. Poor soil structure. Very little competent rock or organic material in the substrate. Virtually no vegetation present.
Photograph 1:	K 14 North end

Photograph 2:	K 14 South end



3.2.2 B-C Waste Dump

Monitoring was undertaken on B-C Waste Dump at sites BC 01 and BC 02 on 31 October 2018. Reference sites KN 06, KN 07 and KN 11 were also completed during the 2018 monitoring period and the results combined with the previous data to provide updated comparative data.

Species richness

The number of native species in each of the monitored waste dump transects ranged from 20 to 21. In comparison the reference sites ranged from 12 to 16 native species per transect.

Abundance

The average number of live native plant individuals per 2 x 2m quadrat in each waste dump transect was 31.9 in BC 01 and 41 in BC 02. The average number of live native plant individuals per 2 x 2m reference site quadrat ranged from 3 to 6.6.

Weeds

Ward's weed (*Carrichtera annua*), Maltese cockspur (*Centaurea melitensis*) and ruby dock (*Rumex vesicarius*) were recorded in the waste dump monitoring sites in November 2018. No weeds were recorded in the reference sites.

General comments

Rehabilitation on B-C Waste Dump has progressed very well, with both sites monitored during 2018 having achieved the closure completion criteria. The waste dump slopes display a high degree of stability with generally very good species diversity.

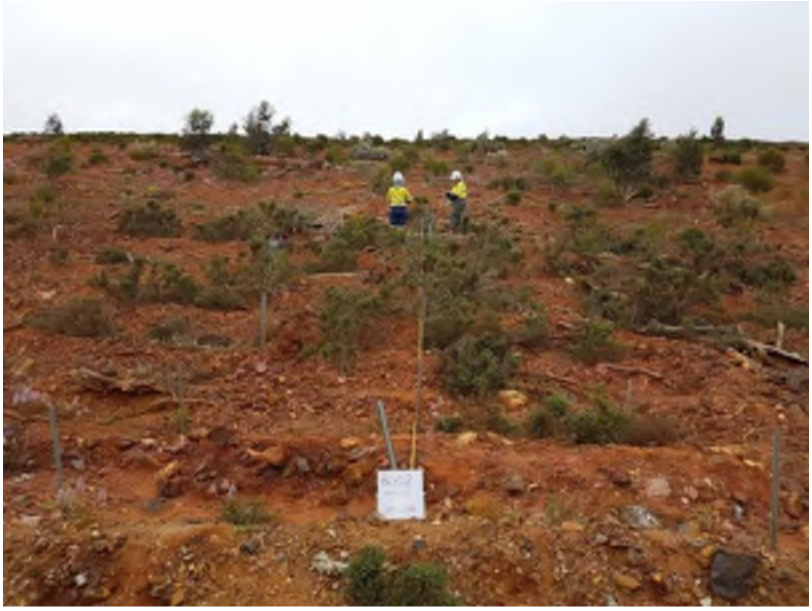
The following pages provide a summary of the data collected and photographs from each of the two B-C Waste Dump rehabilitation monitoring sites completed in November 2018.

Table 3.2 provides a comparison with the closure criteria developed from data obtained from the reference sites.

Site number:	BC 01
Date:	31/10/2018
Vegetation description:	Lower slope: *Eucalyptus griffithsii* very open woodland over *Acacia* spp. open shrubland over mixed Chenopod low shrubland. Upper slope: *Atriplex vesicaria* low shrubland over mixed Chenopod shrubs and herbs.
Erosion:	Minor rilling throughout transect. Appears to be stable. Severity = 1
Comments:	Rehab is progressing well.
Photograph 1:	BC 01 North end

Photograph 2:	BC 01 South end

Site number:	**BC 02**
Date:	31/10/2018
Vegetation description:	*Atriplex vesicaria* and *Atriplex codonocarpa* mid open shrubland over low sparse Chenopod shrubland over *Mesembryanthemum nodiflorum* low sparse herbland
Erosion:	No erosion present
Comments:	Lower portion of transect is less diverse than the upper section.
Photograph 1:	BC 01 North end



Photograph 2: BC 01 South end

3.2.3 A1 and A2 Waste Dump

Monitoring was undertaken on the A1 and A2 waste dump at sites A1 03 and A2 01 on 31 October 2018. Reference sites KN 06, KN 07 and KN 11 were also completed during the 2018 monitoring period and the results combined with the previous data to provide updated comparative data.

Species richness

The number of native species in each of the monitored waste dump transects ranged from 12 in A2 01 to 23 in A1 03. In comparison, the reference sites ranged from 12 to 16 native species per transect.

Abundance

The average number of live native plant individuals per 2 x 2m quadrat in each waste dump transect ranged from 18.4 (A1 04) to 41.9 (A2 01). The average number of live native plant individuals per 2 x 2m reference site quadrat ranged from 3 to 6.6.

Weeds

Ward's weed (*Carrichtera annua*), Maltese cockspur (*Centaurea melitensis*) and ruby dock (*Rumex vesicarius*) were recorded in the waste dump monitoring sites in November 2018. No weeds were recorded in the reference sites.

General comments

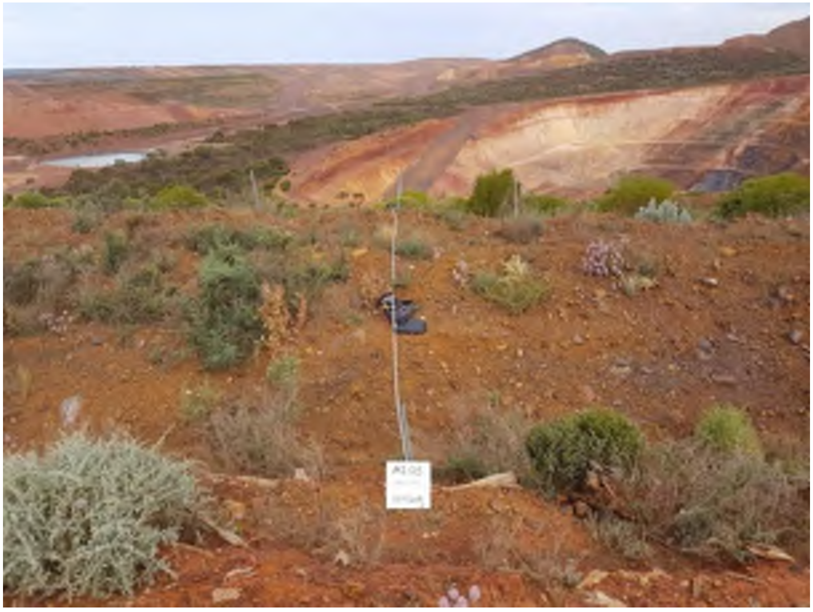
Rehabilitation on the A1 and A2 waste dumps has progressed well, with all sites monitored during 2018 having achieved the closure completion criteria. The waste dump slopes display a high degree of stability.

The following pages provide a summary of the data collected and photographs from each of the A1 and A2 rehabilitation monitoring sites completed in November 2018.

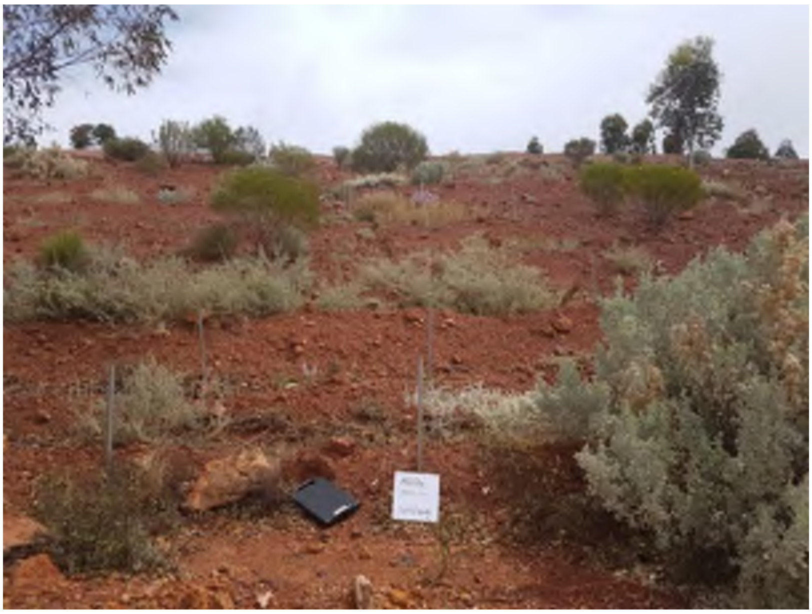
Table 3.3 provides a comparison with the closure criteria developed from data obtained from the reference sites.

Site number:	**A1 03**
Date:	31/10/2018
Vegetation description:	*Acacia acuminata and A. quadrimarginea* shrubland over mixed Chenopod low shrubland.
Erosion:	No erosion present
Comments:	Slope is stable and a diverse range of species are present.
Photograph 1:	A1 03 East end

Photograph 2: A1 03 West end



Site number:	**A1 04**
Date:	31/10/2018
Vegetation description:	*Atriplex nummularia* and *Senna artemisioides* subsp. *filifolia* shrubland over Atriplex vesicaria low shrubland over mixed Chenopod low shrubs and herbs.
Erosion:	Minor gully through Q5-8, now appears to be stable. Severity = 2.
Comments:	Upper 5-8m of transect is predominately bare (extends on to berm).
Photograph 1:	A1 04 North end



Photograph 2: A1 04 South end

Site number:	**A2 01**
Date:	31/10/2018
Vegetation description:	*Eucalyptus* sp. isolated trees over *Acacia acuminata*, *Atriplex nummularia* and *Maireana brevifolia* low shrubland over mixed Chenopod low shrubland.
Erosion:	Minor rilling throughout transect. Severity = 1-2.
Comments:	Upper approx. 5m (west end) of the transect is predominately bare. Appears to have been rehabilitated later than the rest of the transect.
Photograph 1:	A2 01 East end

Photograph 2: A2 01 West end

Table 3.1: K Waste Dump comparison with closure completion criteria.

	Reference Sites			Completion Criteria (70% of average)	Waste Dump Sites																			
	Eucalypt woodland	Acacia shrubland	Salt lake fringing vegetation		K 05	Comparison to previous	K 06	Comparison to previous	K 07	Comparison to previous	K 09	Comparison to previous	K 10	Comparison to previous	K 11	Comparison to previous	K 12	Comparison to previous	K 13	Comparison to previous	K 14	Comparison to previous	K 15	Comparison to previous
Average total live foliage cover per 2x2 (%)	7.7	8.5	13.2	**6.9**	4.4	-	15.6	↑	26.4	-	31.3	↑	24.1	-	26.0	-	20.8	↓	1.6	-	0.5	↑	0.2	-
Average number of live native perennial individuals per 2x2	2.8	3.9	12.7	**4.5**	4.7	-	14.0	↑	7.5	-	26.9	↑	20.4	-	15.5	-	26.0	↑	8.3	-	0.5	↑	0.0	-
Total native species richness	12.7	14.0	16.3	**10.0**	10	-	7	↓	12	-	9	↓	10	-	8	-	12	↑	9	-	7	↑	1	-

Green shading indicates closure criterion has been achieved.

Table 3.2: B-C Waste Dump comparison with closure completion criteria.

	Reference Sites			Completion Criteria (80% of average)	Waste Dump Sites							
	Vegetation Unit 1 Euc. salmonophloia tall open woodland	Vegetation Unit 6 Euc. corrugata low mallee woodland	Vegetation Unit 9 Euc. woodland		BC 01	Comparison to previous	BC 02	Comparison to previous	BC 03	Comparison to previous	BC 04	Comparison to previous
Average total live foliage cover per 2x2 (%)	9.8	10.8	18.4	**10.4**	33.5	↑	24.4	↑	4.7	-	15.6	-
Average number of live native perennial individuals per 2x2	4.9	3.0	3.1	**2.9**	31.9	↑	41.0	↑	10.8	-	7.9	-
Total native species richness	14.3	12.5	1.8	**7.6**	20	↑	21	↑	12	-	17	-

Green shading indicates closure criterion has been achieved.

Table 3.3: A1 and A2 Waste Dumps comparison with closure completion criteria.

	Reference Sites				Waste Dump Sites									
	Eucalypt woodland VU1	**Eucalypt woodland VU6**	**Eucalypt woodland VU9**	**Completion Criteria (80% of average)**	**A1 03**	Comparison to previous	**A1 04**	Comparison to previous	**A1 01**	Comparison to previous	**A1 02**	Comparison to previous	**A2 01**	Comparison to previous
Average total live foliage cover per 2x2 (%)	9.8	10.8	18.4	**10.4**	34.0	↑	17.9	↑	16.4	-	17.6	-	34.0	-
Average number of live native perennial individuals per 2x2	4.9	3.0	3.1	**2.9**	20.1	↑	18.4	↑	8.9	-	20.5	-	41.9	-
Total native species richness	14.3	12.5	1.8	**7.6**	23	↑	17	↑	20	-	13	-	12	-

Green shading indicates closure criterion has been achieved.

3.3 Mt Jackson

3.3.1 J1 Waste Dump

Only two sites, J1 01 and J1 02 have been established on the J1 Waste Dump at this stage. Both sites were monitored on 5 November 2018. Seven reference sites (J1N 01 -07) have recently been established however monitoring of the sites has not yet been undertaken. Previous reference site data (JN 01 – 13) has been used as comparative data at this stage. Reference sites JN 01, JN 06, JN 07 and JN 10 and JN 13 were completed during the 2018 monitoring period and the results combined with the previous reference sites to provide the comparative data used in this report.

Species richness

Fourteen native species were recorded in J1 01 and 24 were recorded in J1 02. In comparison, the reference sites ranged from 5 to 22 native species per transect.

Abundance

The average number of live native plant individuals per 2 x 2m quadrat in each waste dump transect was 20.6 in J1 01 and 21.2 in J1 02. In comparison the average number of live native plant individuals per 2 x 2m reference site quadrat ranged from 3.2 to 10.5.

Weeds

Maltese cockspur (*Centaurea melitensis*) was recorded in the J1 01 monitoring site in November 2018. No weeds were recorded in the reference sites.

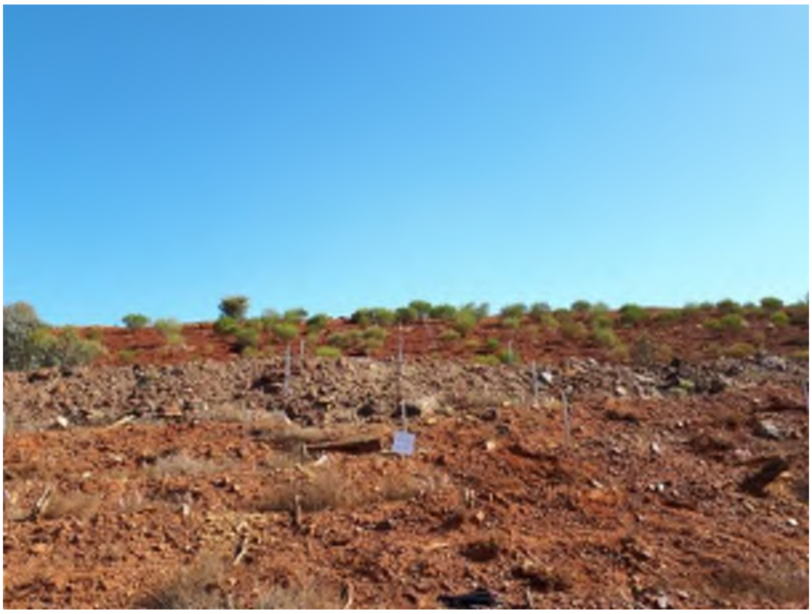
General comments

Rehabilitation on the J1 Waste Dump has progressed well, with both sites monitored during 2018 having achieved two of the three closure completion criteria. The waste dump slopes display a high degree of stability and species diversity is good.

The following pages provide a summary of the data collected and photographs from the J1 rehabilitation monitoring sites completed in November 2018.

Table 3.4 provides a comparison with the closure criteria developed from data obtained from the reference sites.

Site number:	J1 01
Date:	5/11/2018
Vegetation description:	*Acacia acuminata* mid open shrubland over *Maireana tomentosa, Maireana georgei* and *Sclerolaena cuneata* low chenopod shrubland over *Ptilotus nobilis* and *Ptilotus obovatus* low sparse shrubland.
Erosion:	No erosion present
Comments:	Rehab is progressing well.
Photograph 1:	J1 01 North end



Photograph 2: J1 01 South end

Site number:	J1 02
Date:	5/11/2018
Vegetation description:	*Eucalyptus sp.* low trees at north end. *Acacia* sp. Mt Jackson, *Acacia acuminata* shrubland becoming *Acacia* sp. Mt Jackson, *Dodonaea inaequifolia, Acacia ?erinaceae* sparse low shrubland on upper slope.
Erosion:	No erosion present
Comments:	A number of largely bare patches at the time of monitoring, none are greater than 10 x 10m. Site is stable and rehab is progressing well.
Photograph 1:	J1 02 North end

Photograph 2: J1 02 South end

3.3.2 J2 Waste Dump

Monitoring was undertaken for site J2 01 on the J2 Waste Dump. Reference sites JN 01, JN 06, JN 07 and JN 10 and JN 13 were completed during the 2018 monitoring period and the results combined with the previous reference sites to provide the comparative data used in this report.

Species richness

Thirteen native species were recorded in the J2 01 transect. In comparison, the reference sites ranged from 5 to 22 native species per transect.

Abundance

The average number of live native plant individuals per 2 x 2m quadrat in the J2 01 transect was 6.2. In comparison, the average number of live native plant individuals per 2 x 2m reference site quadrat ranged from 3.2 to 10.5.

Weeds

No weed species were recorded in the J2 01 monitoring site in November 2018 and no weeds were recorded in the reference sites.

General comments

Rehabilitation on the J2 Waste Dump has progressed well, with all of the completion criteria having been met in site J2 01. Two of the three closure criteria have improved since the last monitoring was undertaken. The waste dump slopes display a moderate degree of stability, having been constructed at a steeper angle than later rehabilitation.

The following page provides a summary of the data collected and photographs from the J2 01 rehabilitation monitoring site completed in November 2018.

Table 3.4 provides a comparison with the closure criteria developed from data obtained from the reference sites.

Site number:	**J2 01**
Date:	5/11/2018
Vegetation description:	*Acacia acuminata, Acacia burkittii, Grevillea juncifolia* mid open shrubland over *Westringia cephalantha, Hibbertia exasperata* and *Leucopogon* sp. Clyde Hill *l*ow sparse shrubland over *Maireana georgei, Maireana tomentosa* low sparse chenopod shrubland.
Erosion:	Minor gully erosion/washouts from Q13-Q20. A single gully running almost the length of the transect on the northern side. Severity = 2
Comments:	Bare areas throughout the transect but none are greater than 10 x 10m.
Photograph 1:	J2 01 East end

Photograph 2:	J2 01 West end

3.3.3 J3 Waste Dump

Monitoring was undertaken for site J3 03 on the J3 Waste Dump. Reference sites JN 01, JN 06, JN 07 and JN 10 and JN 13 were completed during the 2018 monitoring period and the results combined with the previous reference sites to provide the comparative data used in this report.

Species richness

Twenty native species were recorded in the J3 03 transect. In comparison the reference sites ranged from 5 to 22 native species per transect.

Abundance

The average number of live native plant individuals per 2 x 2m quadrat in the J3 03 transect was 10.2. In comparison the average number of live native plant individuals per 2 x 2m reference site quadrat ranged from 3.2 to 10.5.

Weeds

No weed species were recorded in the J3 03 monitoring site in November 2018 and no weeds were recorded in the reference sites.

General comments

Rehabilitation on the J3 Waste Dump has progressed well, with J3 03 having achieved two of the three closure completion criteria. The waste dump slopes display a high degree of stability and species diversity is typically very good on the lower slopes. The upper slopes were completed at a later date and rehabilitation has not yet progressed to the extent of the lower slopes.

The following page provides a summary of the data collected and photographs from the J3 03 rehabilitation monitoring site completed in November 2018.

Table 3.4 provides a comparison with the closure criteria developed from data obtained from the reference sites.

Site number:	**J3 03**
Date:	5/11/2018
Vegetation description:	*Acacia acuminata, Calycopeplus paucifolius* shrubland over mixed small shrubs and herbs.
Erosion:	Minor rilling throughout the transect. Severity = 1
Comments:	Slope is stable and a diverse range of species are present.
Photograph 1:	J3 03 North end

Photograph 2: J3 03 South end

Table 3.4: J1, J2 and J3 Waste Dumps comparison with closure completion criteria.

	Reference Sites						Waste Dump Sites															
	Allocas. shrubland	**Allocas. & Acacia shrubland**	**Eucalypt woodland 1**	**Eucalypt woodland 2**	**Acacia shrubland**	**Completion Criteria (70% of average)**	**J1 01**	Comparison to previous	**J1 02**	Comparison to previous	**J2 01**	Comparison to previous	**J2 02**	Comparison to previous	**J2 03**	Comparison to previous	**J3 01**	Comparison to previous	**J3 02**	Comparison to previous	**J3 03**	Comparison to previous
Average total live foliage cover per 2x2 (%)	14.3	23.8	22.5	15.4	36.8	**14.1**	7.5	-	10.0	-	15.4	↑	4.7	-	4.6	-	4.3	-	3.5	-	11.5	↑
Average number of live native perennial individuals per 2x2	3.1	5.9	4.8	4.8	10.5	**3.2**	20.6	-	21.2	-	6.2	↑	2.1	-	16.1	-	7.0	-	3.6	-	10.2	↓
Total native species richness	6.0	20.3	2.8	9.0	16.0	**6.8**	10	-	23	-	13	↓	14	-	12	-	20	-	20	-	20	↑

Green shading indicates closure criterion has been achieved.

3.4 Windarling

3.4.1 W2 Waste Dump

Monitoring was undertaken for sites W2 01, W2 02 and W2 05 on the W2 Waste Dump. Reference sites WN 02, WN 04, WN 06 and WN 09 and WN 15 were completed during the 2018 monitoring period and the results combined with the previous reference sites to provide the comparative data used in this report.

Species richness

The number of native species in each of the monitored waste dump transects ranged from nine in W2 05 to 17 in W2 02. In comparison, the reference sites ranged from 6 to 24 native species per transect.

Abundance

The average number of live native plant individuals per 2 x 2m quadrat ranged from 14 to 36. In comparison, the average number of live native plant individuals per 2 x 2m reference site quadrat ranged from 2 to 8.8.

Weeds

Maltese cockspur (*Centaurea melitensis*) was recorded in the W2 01 monitoring site in November 2018. No weeds were recorded in the reference sites.

General comments

Rehabilitation on the W2 Waste Dump has generally progressed well, with W2 01, W2 02 and W2 05 having achieved all three closure completion criteria.

The following pages provide a summary of the data collected and photographs from the W2 rehabilitation monitoring sites completed in November 2018.

Table 3.5 provides a comparison with the closure criteria developed from data obtained from the reference sites.

Site number:	**W2 01**
Date:	4/11/2018
Vegetation description:	*Acacia ?caesaneura* low sparse shrubland over *Maireana tomentosa, Sclerolaena cuneata* and *Salsola australis* low open chenopod shrubland over *Ptilotus nobilis* and *Roepera aurantiaca* low sparse herbland.
Erosion:	Minor rilling present throughout transect. Severity = 1
Comments:	A lot of plant deaths at the time of monitoring.
Photograph 1:	W2 01 North end

Photograph 2: W2 01 South end

Site number:	**W2 02**
Date:	4/11/2018
Vegetation description:	Very open *Eucalyptus* low woodland over *Acacia shrubland* over *Ptilotus obovatus* and mixed Chenopod species.
Erosion:	Minor gullying down left hand side of transect on 2nd lift. Appears stable. Severity = 2
Comments:	Very little understorey vegetation present.
Photograph 1:	W2 02 North end

Photograph 2: W2 02 South end

Site number:	W2 05
Date:	4/11/2018
Vegetation description:	*Acacia caesaneura*, *A. fuscaneura* and *A. ramulosa* open shrubland over mixed Chenopod very open low herbs.
Erosion:	Minor rilling on lower level. Severity = 1-2
Comments:	Very little understorey species present.
Photograph 1:	W2 05 North end

Photograph 2: W2 05 South end

3.4.2 W3 Waste Dump

Monitoring was undertaken for sites W3 01, W3 04 and W3 05 on the W3 Waste Dump. There has been no prior monitoring of the sites on W3 Waste Dump. Reference sites WN 02, WN 04, WN 06 and WN 09 and WN 15 were completed during the 2018 monitoring period and the results combined with the previous reference sites to provide the comparative data used in this report.

Species richness

The number of native species in each of the monitored waste dump transects ranged from eight in W3 05 to 13 in W3 04. In comparison the reference sites ranged from 6 to 24 native species per transect.

Abundance

The average number of live native plant individuals per 2 x 2m quadrat ranged from 5.3 to 13.7. In comparison the average number of live native plant individuals per 2 x 2m reference site quadrat ranged from 2 to 8.8.

Weeds

Maltese cockspur (*Centaurea melitensis*) was recorded in the W3 01 monitoring site in November 2018. No weeds were recorded in the reference sites.

General comments

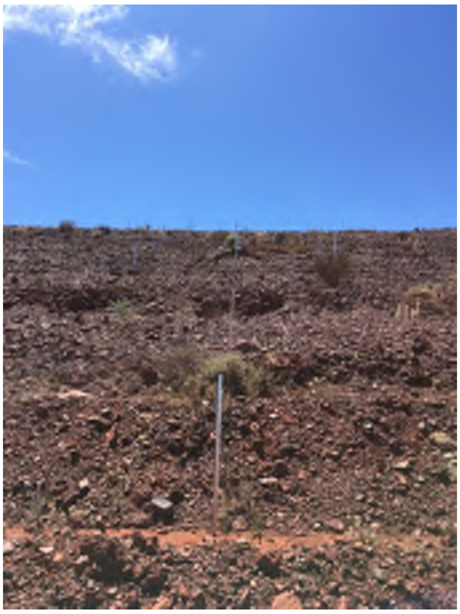
Rehabilitation on the W3 Waste Dump has progressed well in some areas, but was completed relatively recently on much of the waste dump. W3 01, W3 04 and W3 05 have each achieved two of the three closure completion criteria to date.

The following pages provide a summary of the data collected and photographs from the W3 rehabilitation monitoring sites completed in November 2018.

Table 3.5 provides a comparison with the closure criteria developed from data obtained from the reference sites.

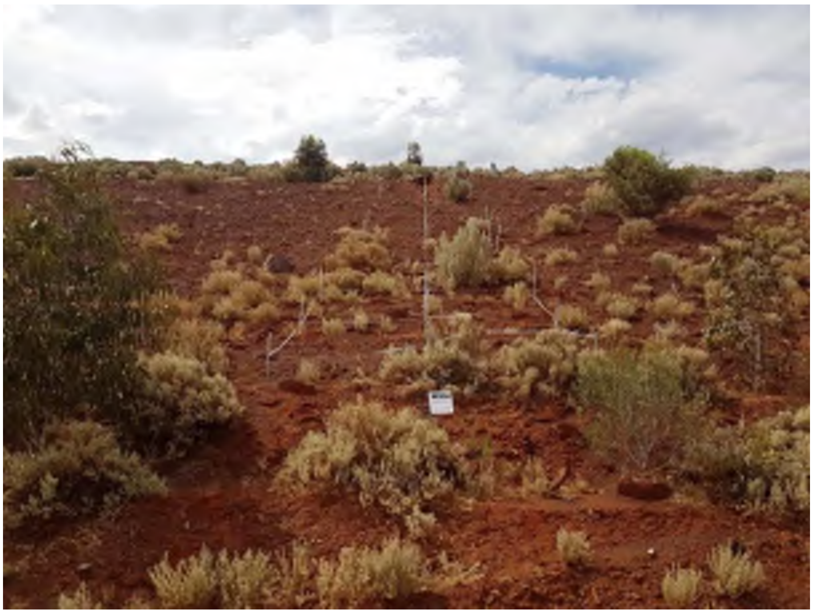
Site number:	**W3 01**
Date:	4/11/2018
Vegetation description:	*Salsola australis, Sclerolaena cuneata* and *Sclerolaena diacantha* low sparse chenopod shrubland over *Ptilotus nobilis* low sparse shrubland.
Erosion:	Top half of transect has gully erosion. Severity = 2
Comments:	
Photograph 1:	W3 01 East end

Photograph 2:	W3 01 West end



Site number:	W3 04
Date:	4/11/2018
Vegetation description:	Transect: *Atriplex* open shrubland. Broader area: *Isolated Eucalyptus griffithsii* low woodland over *Acacia* isolated tall shrubs.
Erosion:	Minor rilling throughout the transect. Severity = 1
Comments:	Slope is stable, species diversity is quite good.
Photograph 1:	W3 04 North end

Photograph 2: W3 04 South end



Site number:	W3 05
Date:	4/11/2018
Vegetation description:	*Salsola australis* and *Maireana georgei* low sparse shrubland over **Centaurea melitensis* and *Ptilotus nobilis* low sparse herbland.
Erosion:	Minor rilling throughout transect - Severity = 1-2. More significant gully erosion at the base of the transect (East end) - Severity = 2-3.
Comments:	Maltese cockspur prevalent.
Photograph 1:	W3 05 East end

Photograph 2: W3 05 West end

Table 3.5: W2 Waste Dump comparison with completion criteria.

	Reference Sites						Waste Dump Sites													
	Eucalypt low woodland	Acacia shrubland 1	Eucalypt woodland	Acacia shrubland 2	Acacia shrubland 3	Completion Criteria (70% of average)	W2 01	Comparison to previous	W2 02	Comparison to previous	W2 03	Comparison to previous	W2 04	Comparison to previous	W2 05	Comparison to previous	W2 06	Comparison to previous	W2 07	Comparison to previous
Average total live foliage cover per 2x2 (%)	16.0	43.0	16.7	8.2	27.8	**17.6**	18.7	↑	22.6	↑	4.1	-	4.5	-	25.0	↑	4.1	-	4.5	-
Average number of live native perennial individuals per 2x2	2.2	4.6	6.4	6.4	4.4	**3.1**	36.0	↑	22.0	↑	2.0	-	4.5	-	14.0	↑	2.0	-	4.5	-
Total native species richness	11.3	6.7	2.6	9.7	12.7	**4.8**	11	↓	17	↓	11	-	15	-	9	↓	11	-	15	-

Green shading indicates closure criterion has been achieved.

Table 3.6: W3 Waste Dump comparison with completion criteria.

	Reference Sites						Waste Dump Sites					
	Eucalypt low woodland	Acacia shrubland 1	Eucalypt woodland	Acacia shrubland 2	Acacia shrubland 3	Completion Criteria (70% of average)	W3 01	Comparison to previous	W3 04	Comparison to previous	W3 05	Comparison to previous
Average total live foliage cover per 2x2 (%)	16.0	43.0	16.7	8.2	27.8	**17.6**	6.4	-	13.3	-	4.0	-
Average number of live native perennial individuals per 2x2	2.2	4.6	6.4	6.4	4.4	**3.1**	13.7	-	12.5	-	5.3	-
Total native species richness	11.3	6.7	2.6	9.7	12.7	**4.8**	11	-	13	-	8	-

Green shading indicates closure criterion has been achieved.

4.0 DISCUSSION

The results of monitoring undertaken of the Koolyanobbing, Mt Jackson and Windarling sites demonstrate that rehabilitation is generally progressing well across the project. Monitoring carried out to date has demonstrated that 15 of the 34 monitoring sites have achieved all of the closure completion criteria. A further 16 sites have achieved two of the three closure criteria. Most of the deficient sites are lacking sufficient live foliar cover to achieve the closure criterion. In most cases this will increase over time as the perennial plants increase in size. A different result may also be achieved depending on the timing of conducting monitoring. Annual and short-lived species had mostly died off by the time the monitoring was undertaken in November 2018.

K Waste Dump has the lowest species diversity (species richness) of all of the rehabilitation sites across the project, with an average of nine species per 2 x 2m transect. Three of the ten K Waste Dump monitoring sites have achieved closure completion criteria however most of the remainder are deficient in species richness. Seeding with salt-tolerant species found in the surrounding area may need to be considered. K 14 and K 15, the sites at the southern end of the waste dump, have soils that are not conducive to rehabilitation and subsequently have not achieved any of the closure criteria to date. Trial seeding with highly salt tolerant species such as *Tecticornia* ("Samphire") and *Atriplex* ("Saltbush") species may be worthwhile in these areas.

The monitoring sites on the A1 and A2 waste dumps have all achieved the closure criteria. Three of the four sites on the BC Waste Dump have achieved the closure criteria.

Revegetation of the completed areas of J1 waste dump has progressed very well in the relatively short time since rehabilitation was completed, with both sites monitored having achieved two of the three closure criteria. Revegetation success on the J2 Waste Dump is variable, likely due to the relatively steep slopes (approximately 20°). The site monitored during 2018 has achieved each of the closure criteria. The other two sites were lacking in live foliage cover when last monitored. The J3 rehabilitation monitoring sites are also lacking in live foliage cover when compared to the surrounding undisturbed reference monitoring sites, however the other closure criteria have been achieved.

The three rehabilitation sites monitored on the W2 Waste Dump in 2018 have now achieved each of the closure criteria, despite evidence of grazing by cattle, rabbits and kangaroos. The three sites monitored on W3 waste dump have achieved two of the three closure criteria, again lacking in live foliage cover.

Weed species are present in most of the waste dump monitoring sites across the project, however have not been recorded in any of the native vegetation reference sites. An interim closure criterion for weeds was included in the Cliffs 2013 Rehabilitation Monitoring Program Pilot Study and stated that "Coverage of weed species is less than the average of three reference sites on nearby land". The current weed abundance is not considered to be detrimental to the ability of native species to revegetate the rehabilitated areas, however, given that the reference sites do not support any weed species, it is considered unlikely that this criterion will be achievable for many of the rehabilitation sites.

5.0 RECOMMENDATIONS

5.1 Data collection

A considerable portion of the data collected during monitoring is not used in assessment of progress toward achievement of completion criteria. Data collection could be refined to make the process quicker and more efficient. For example:

- rather than assessing each 2 x 2m quadrat for live and dead foliar cover, leaf litter cover, exposed rock and bare ground, the assessment could be undertaken for each 4 x 4m quadrat.
- the percentage of live and dead foliage for individual plants is quite subjective, time consuming and not necessary for calculation of the current closure criteria. The number of live and dead individuals is sufficient information for the current closure criteria.
- foliar cover for trees in the 50 x 10m transect is difficult to estimate and is probably more effectively carried out using high resolution aerial imagery.
- the % rock cover and % bare ground assessment requires clarification (i.e. is rock without plant cover also considered bare ground?). The value of this data is uncertain. It may be more useful to describe the substrate and bare areas in the comments. Assessment of the % live and dead foliage is sufficient for determining closure completion criteria.
- data and comments that are unlikely to change between monitoring events (i.e. rock cover/substrate and vegetation description for reference sites, along with the previous species list could be pre-populated in the data collection sheets.

5.2 Monitoring site layout

The numbering sequence of the 2 x 2m quadrats has not been consistent in previous data collection. Ecotec understands that the sequence should be:

4	3
1	2

↑

Start of transect

Although most previous monitoring appears to have been using this anti-clockwise sequence, some sites have been done in a clockwise direction. While this does not change the overall outcome of data collected from the site, the inconsistency may cause confusion when comparing data from different monitoring events.

It is recommended that the procedure be updated to specify the numbering sequence to be applied to the 2 x 2m quadrats.

5.3 Timing

The 2018 monitoring was undertaken late in the season, resulting in many annual species potentially not being present, and many species having finished flower and fruiting, making identification difficult.

It is recommended that future monitoring be undertaken between August and October to take advantage of spring flowering and the presence of annual and short-lived species.

It is also recommended that, if the monitoring work is outsourced to a consultant, more time is allowed for pre-monitoring preparation to enable data sheets to be prepared, species name currency to be confirmed etc.

5.4 "Trees" vs. "shrubs"

Previous data collection had recorded numerous species as "trees", which were considered by the Ecotec field team to be tall shrubs. For example *Acacia acuminata*, *A. ramulosa*, *A*. sp. Mt Jackson, *Allocasuarina eriochlamys*, *Grevillea obliquistigma* and a number of others have previously been recorded as "trees", however are described in Florabase (DPAW 2018) as shrubs.

Florabase (https://florabase.dpaw.wa.gov.au/help/glossary) defines a tree as:

"*A woody plant usually over 5 m high and with an unbranched lower axis*".

The Oxford Dictionary (https://en.oxforddictionaries.com) defines a tree as:

"*A woody perennial plant, typically having a single stem or trunk growing to a considerable height and bearing lateral branches at some distance from the ground*".

As a result, the tree data collected in 2018 could suggest that significantly fewer "trees" are present across most of the reference and rehabilitation monitoring sites. For this reason tree data has not been included in the results in this report. Foliage cover, which is one of the closure criteria, includes tree species occurring in the transect. The species recorded as trees are included in the raw data, which is provided as Appendix 3.

It is recommended for future monitoring that a clear definition of a tree, and the species to be recorded as trees, be included in the monitoring procedure.

5.5 "Annual" species

There appears to have been some discrepancy in previous recordings of annual and perennial species, particularly weed species.

An annual plant is defined by Florabase as "completing the full cycle of germination to fruiting within a single year and then dying". As such, all of the weeds present in the monitoring sites at the Koolyanobbing, Mt Jackson and Windarling sites should be considered annuals. The data collection sheets and previous data provided state that only "perennial weeds" should be recorded, yet Maltese cockspur (*Centaurea melitensis*), Ward's weed (*Carrichtera annua*) and ruby dock (*Rumex vesicarius*), generally considered to be annuals, have been recorded in the data.

Annual native species play an important role in rehabilitation, adding organic material and nutrients to the soil, assisting in stabilisation of soils and aiding establishment of perennial species. The presence of annual native species could be considered an indicator of a healthy developing ecosystem and should be recorded during data collection.

It is recommended that future data collection include all species present and that the term "annual" be replaced with "annual or short-lived".

5.6 Vegetation condition

The procedure for conducting monitoring requires a description of vegetation condition using the condition scale of Keighery (1994). This is achievable for the undisturbed reference sites however vegetation condition cannot be accurately assessed using this scale on waste dumps. According to the scale, even the very best examples of waste dump rehabilitation would be considered "Poor" or "Degraded" due to the level of disturbance.

It is recommended that an alternate scale be developed (or sourced) for assessment of vegetation condition in rehabilitated areas.

5.7 Species name changes and identification

There are a number of species that have had name changes since the original reference and monitoring data was collected. While this does not change the results, comparison of the current and previous species lists will demonstrate some differences.

Previously recorded larger specimens of *Acacia* sp. Mt Jackson are considered by the Ecotec field team to be *Acacia quadrimarginea*, described by Florabase (WA Herbarium 2018) as a “shrub or tree, 1.5 – 6m high”. *Acacia* sp. Mt Jackson is described by the same source as a “shrub, to 2 m high”. As such, there is a change in the species present for a number of sites.

It is recommended that a review of species names be undertaken prior to the next round of monitoring and that sufficient time be allowed prior to commencing the monitoring work to pre-populate the field data sheets with current species names.

5.8 Incidental species

Currently the data collected does not include a list of “incidental” species for each transect, being those found within the transect but not recorded in any of the quadrats. This information may increase the species richness figures for many of the transects by including species that are not presently recorded.

5.9 “In” vs. “overhanging” the quadrat

It appears that during previous monitoring events, plants substantially overhanging quadrats have been recorded as being in the quadrat. This requires clarification to maintain consistency.

It is recommended that only plants with the main stem (or the greater portion of the main stem) rooted within the quadrat be recorded for that quadrat. The overhanging plants can be noted in the comments and included as incidentals if not recorded in other quadrats.

It is also recommended that what is to be recorded as foliage cover for the transect is clarified. For example, should this include tall trees that have canopy overhanging the quadrat, or is it just the cover provided by the plants that are located within the quadrats? Analysis of high resolution aerial imagery may reduce the subjectivity of the current method of foliage cover.

5.10 Data analysis spreadsheet

The existing spreadsheets are cumbersome and prone to data entry errors. The previous data provided included many manual entries of calculation results that should have been set up to automatically calculate from other data in the spreadsheet. To save time, remove the margin for error and provide a more consistent approach to calculation of the required results, it is recommended that the spreadsheets be revised and improved. For example:

- a fixed number of rows (based on the maximum likely) for “Perennials”, “Annuals/Short-lived” and “Weeds” would remove the need for revision of the calculations in each data set
- columns could be included for “Trees (>1.3m)” and “Seedlings (<1.3m)” and calculations set up to include the results in the comparison with reference sites and closure criteria tables.

6.0 REFERENCES

Cliffs Asia Pacific Iron Ore. 2013. *Rehabilitation Monitoring Program Pilot Study Summary*. Revision 0, September 2013.

Cliffs Asia Pacific Iron Ore. 2015. *EOPXX Rehabilitation Monitoring*. Revision 0, March 2015.

Cliffs Asia Pacific Iron Ore. 2012-2015?. *Waste dump and reference site monitoring data spreadsheets for Koolyanobbing, Mt Jackson and Windarling*.

Cliffs Asia Pacific Iron Ore. 2016. *Mt Jackson Rehabilitation Monitoring*. Revision 0, April 2016.

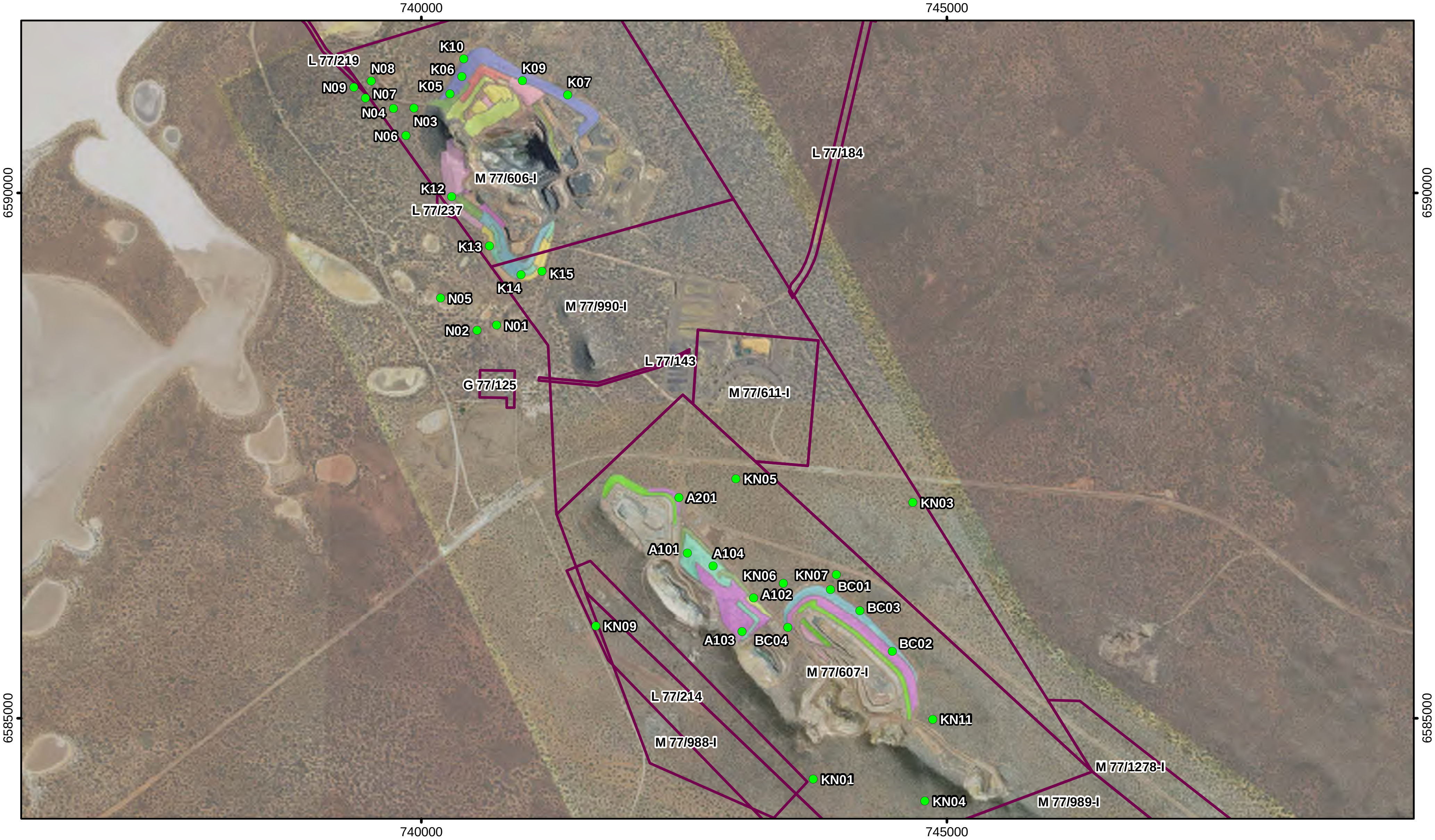
Cliffs Asia Pacific Iron Ore. 2017. *Koolyanobbing Rehabilitation Monitoring* (Koolyanobbing specific). Revision 0, March 2017.

Cliffs Asia Pacific Iron Ore. 2017. *Koolyanobbing Rehabilitation Monitoring Report* (Windarling specific) Revision 0, March 2017.

Western Australian Herbarium. 2018. *FloraBase—the Western Australian Flora*. Department of Biodiversity, Conservation and Attractions. https://florabase.dpaw.wa.gov.au/. Website accessed November 2018.

Appendix 1

Site plans



Legend

- Monitoring Transect
- Tenement

Rehab Year

2004	2005	2009	2014
	2006	2010	2015
	2007	2012	
	2008	2013	

N

0 490 980m

Scale: 1:50,000
MGA94 (Zone 50)

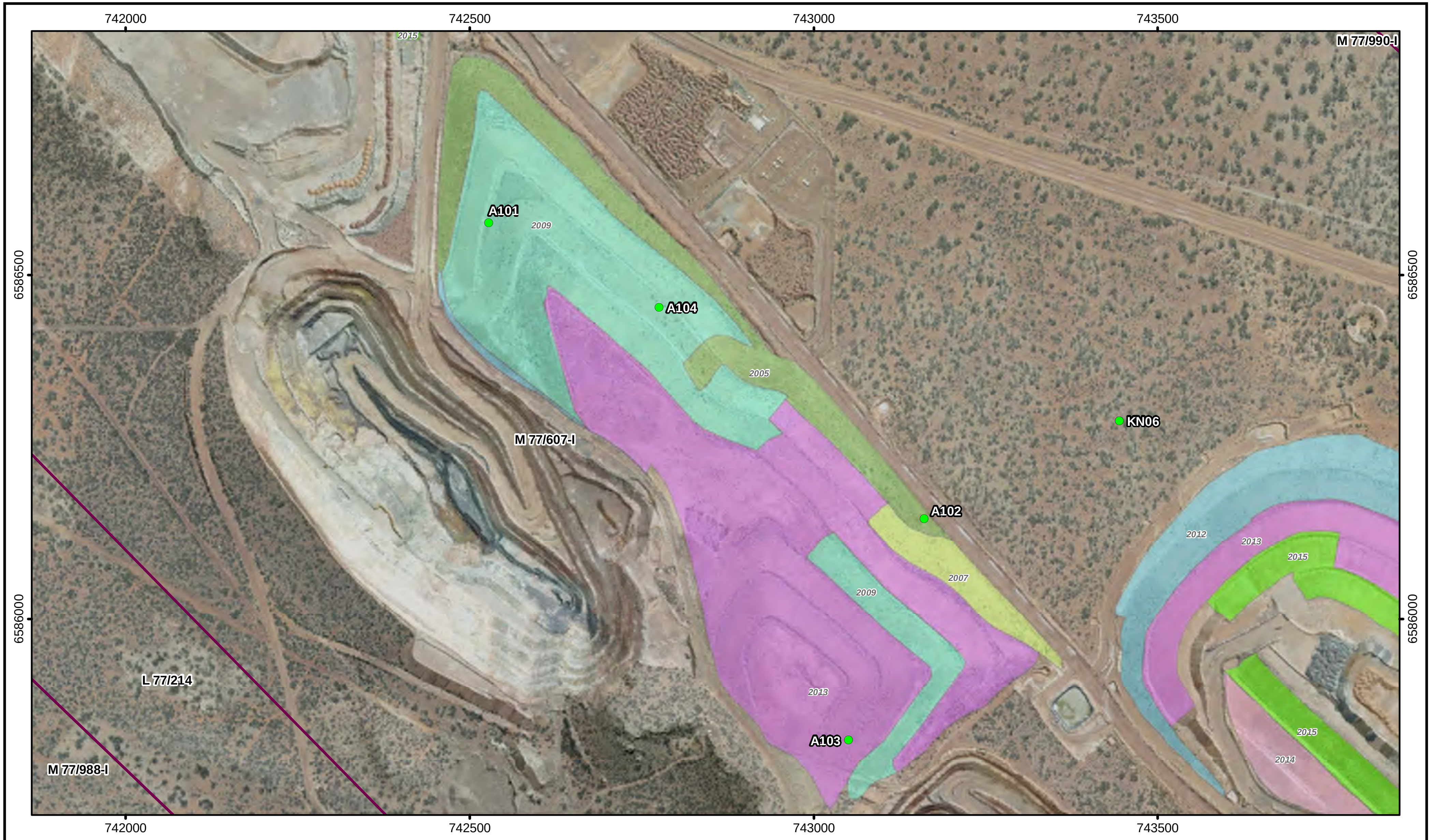
CAD Ref: g836ml289_K01

Date: April 2018 | Rev: A | A4

Author: D. Radovic

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

Koolyanobbing
All Monitoring Transects



Legend

- Monitoring Transect
- Tenement

Rehab Year

- 2005
- 2007
- 2009
- 2012
- 2013
- 2014
- 2015

N

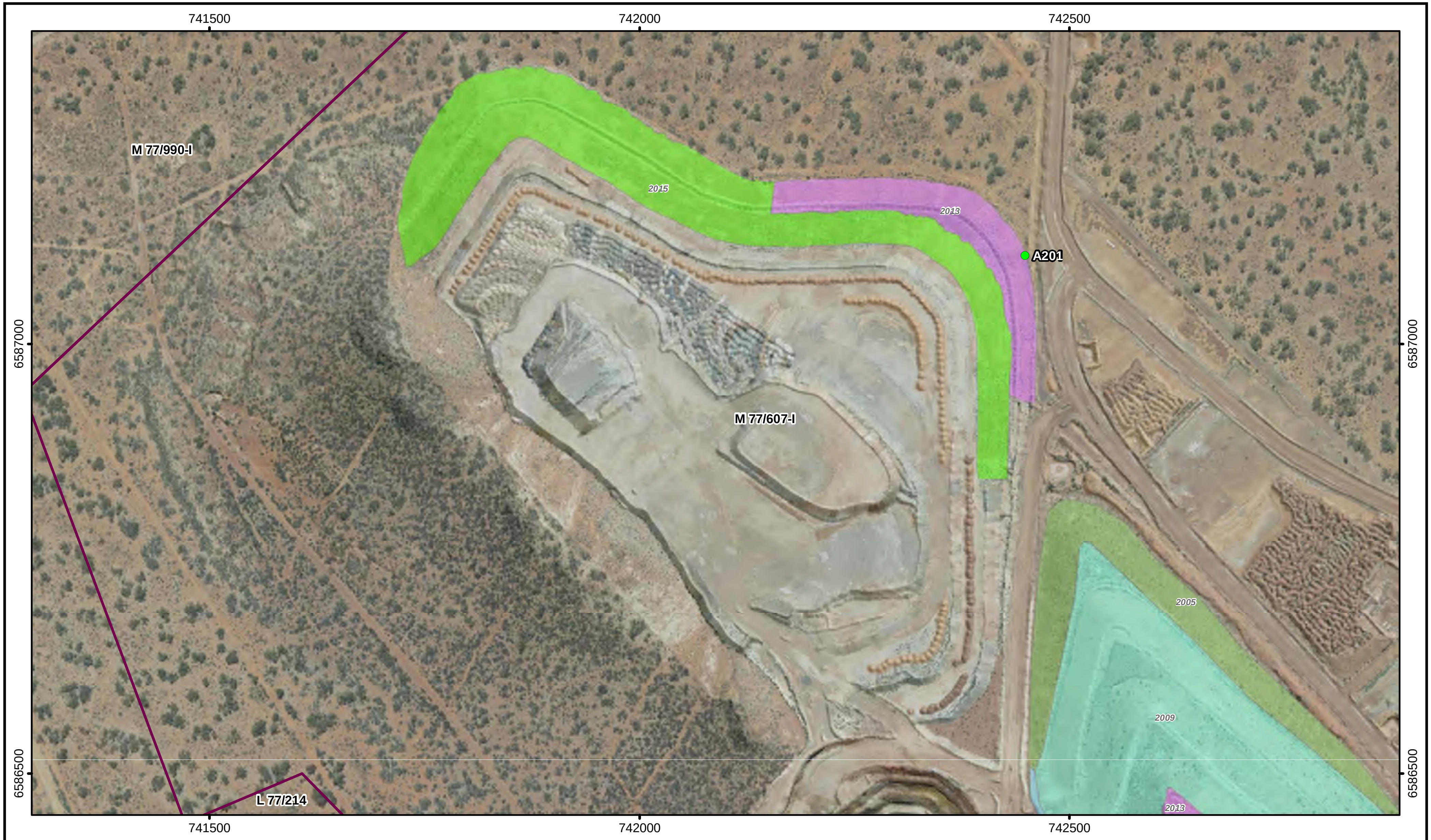
0 75 150m

Scale: 1:7,500
MGA94 (Zone 50)

CAD Ref: g836ml289_K04
Date: April 2018 | Rev: A | A4

Author: D. Radovic
Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

A1 Waste Dump Monitoring Transects



Legend

- Monitoring Transect
- Tenement

Rehab Year

- 2005
- 2009
- 2012
- 2013
- 2015

N

0 60 120 m

Scale: 1:6,000
MGA94 (Zone 50)

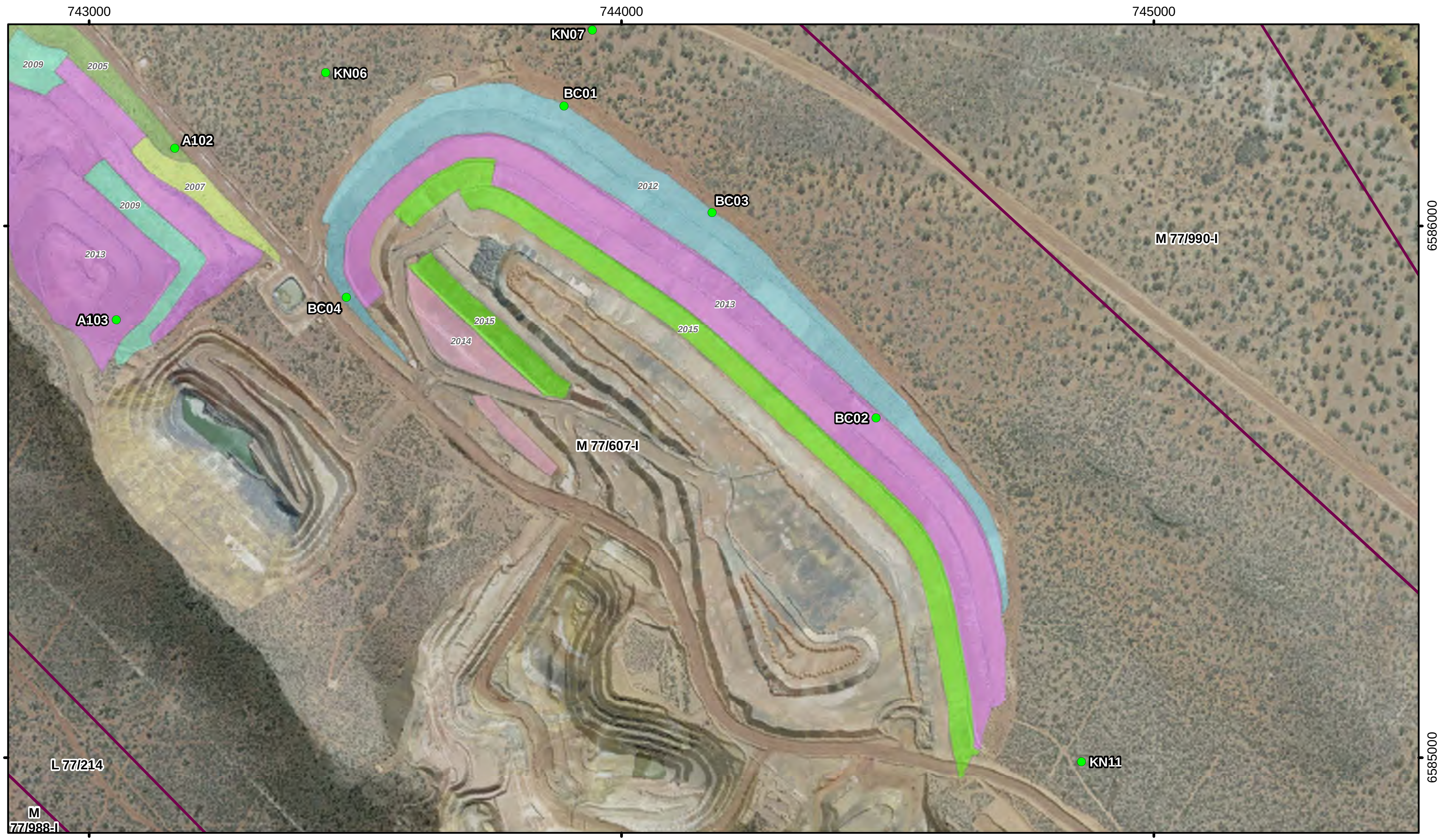
CAD Ref: g836ml289_K03

Date: April 2018 | Rev: A | A4

Author: D. Radovic

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

A2 Waste Dump Monitoring Transect



Legend

- Monitoring Transect
- Tenement

Rehab Year

- 2005
- 2007
- 2009
- 2012
- 2013
- 2014
- 2015

N

0 100 200 m

Scale: 1:10,000
MGA94 (Zone 50)

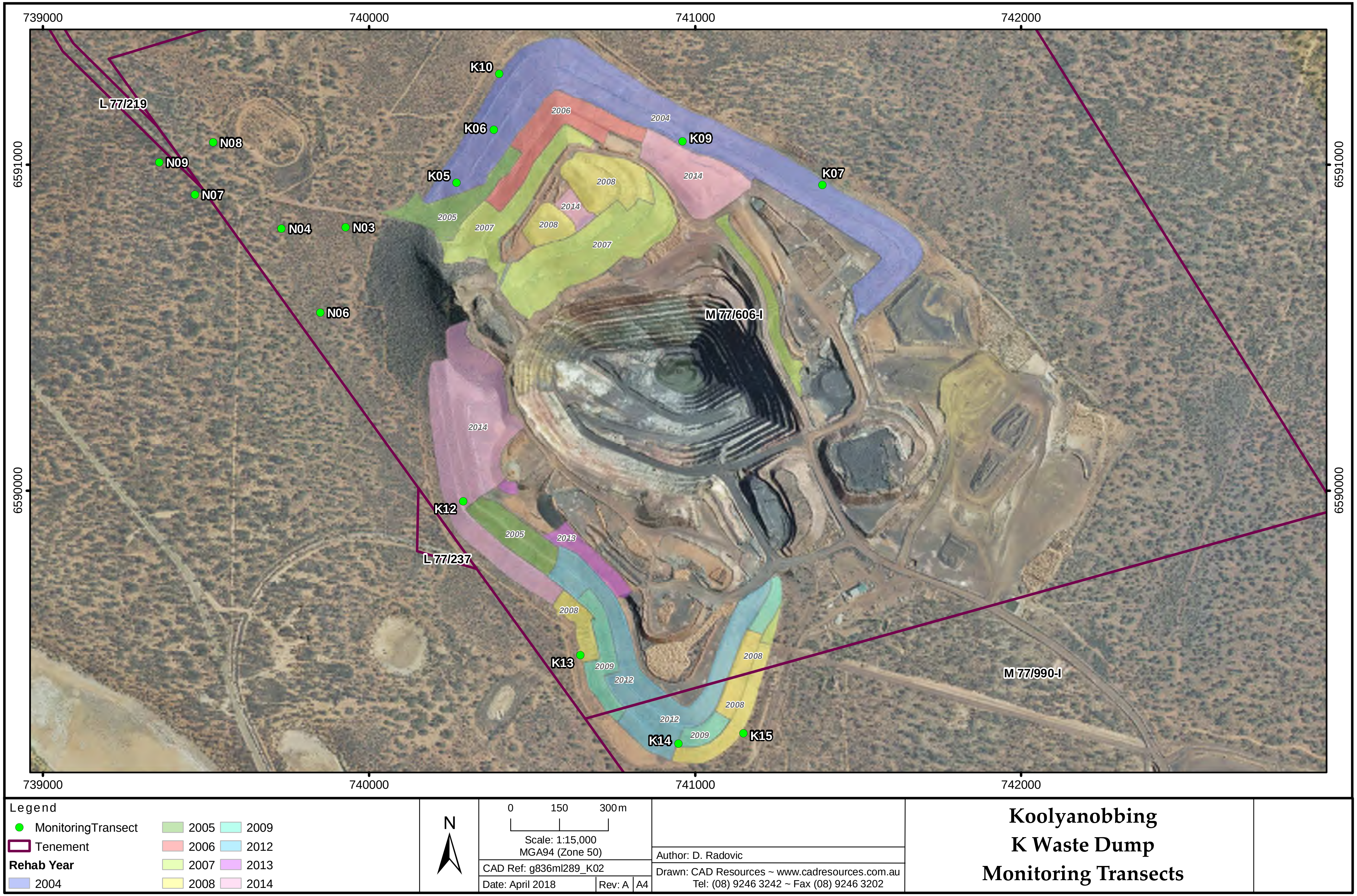
CAD Ref: g836ml289_K05

Date: April 2018 | Rev: A | A4

Author: D. Radovic

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

B-C Waste Dump Rehabilitation Monitoring Transects



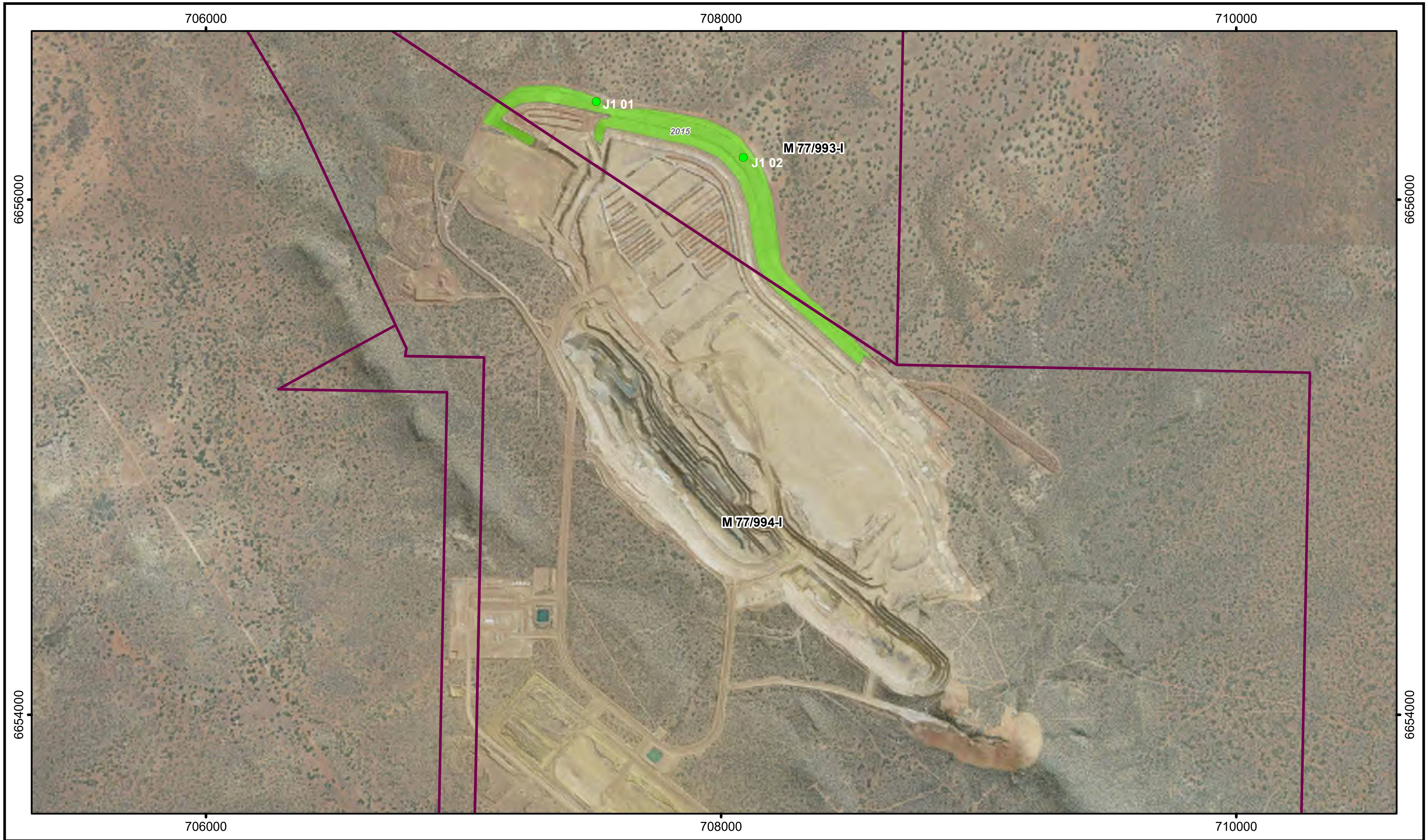
CAD Ref: g836ml289_K02

Date: April 2018 | Rev: A | A4

Author: D. Radovic

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

Koolyanobbing K Waste Dump Monitoring Transects



Legend

- Monitoring Transect
- Tenement

Rehab Year

- 2015

N

0 200 400 m

Scale: 1:20,000
MGA94 (Zone 50)

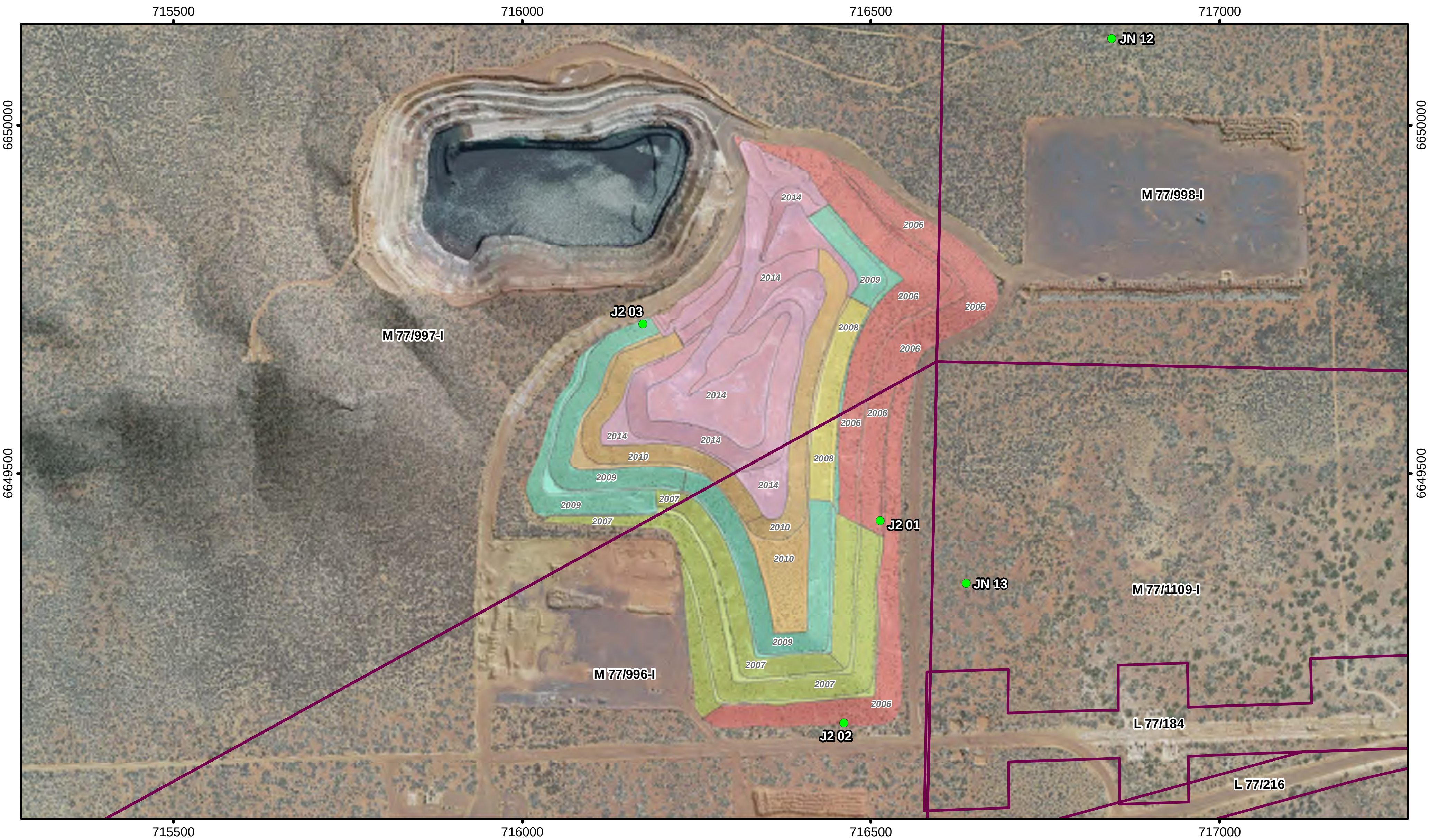
CAD Ref: g836ml289_J04

Date: April 2018 | Rev: A | A4

Author: D. Radovic

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

J1 Waste Dump Monitoring Transects



Legend

- Monitoring Transect
- Tenement

Rehab Year

- 2006
- 2007
- 2008
- 2009
- 2010
- 2014

N

0 75 150 m

Scale: 1:7,500
MGA94 (Zone 50)

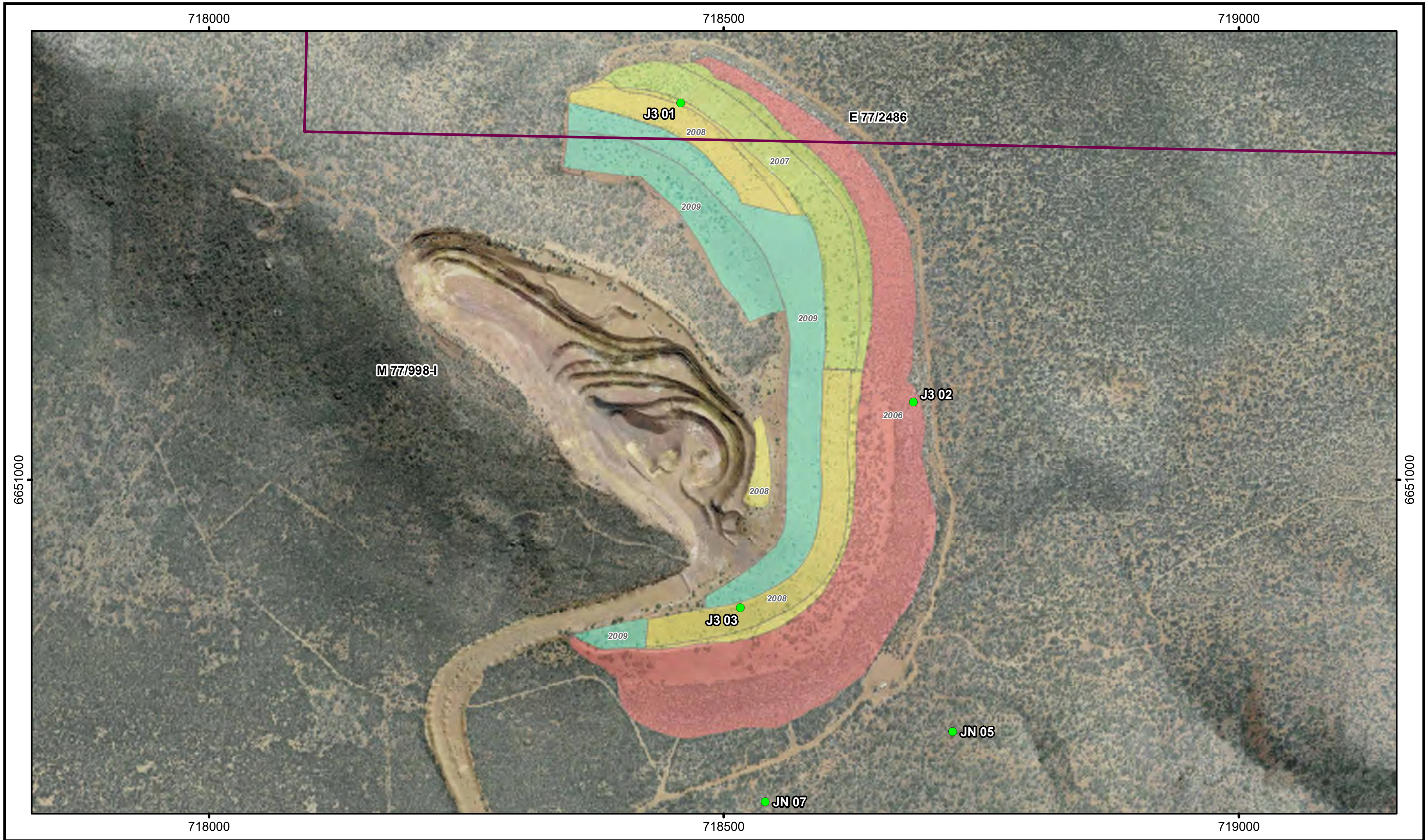
CAD Ref: g836ml289_J03

Date: April 2018 | Rev: A | A4

Author: D. Radovic

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

J2 Waste Dump Monitoring Transects



Legend

Monitoring Transect
Tenement
Rehab Year
2006
2007
2008
2009

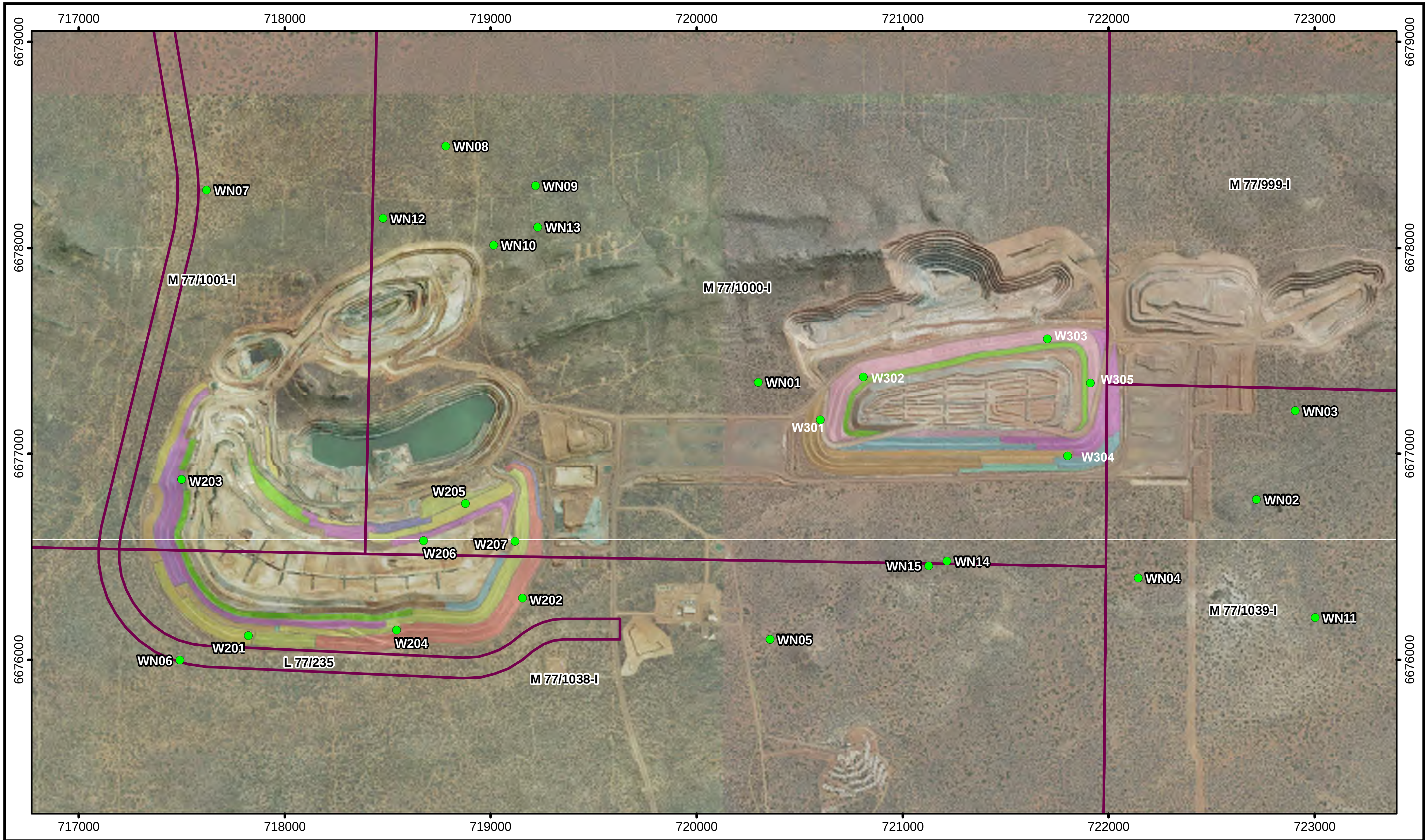
N

0 50 100 m
Scale: 1:5,000
MGA94 (Zone 50)

CAD Ref: g836ml289_J05
Date: April 2018 | Rev: A | A4

Author: D. Radovic
Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

J3 Waste Dump
Monitoring Transects



Legend

- Monitoring Transect
- Tenement

Rehab Year

2004	2006	2010	2014
	2007	2011	2015
	2008	2012	
	2009	2013	

N

0 250 500 m

Scale: 1:25,000
MGA94 (Zone 50)

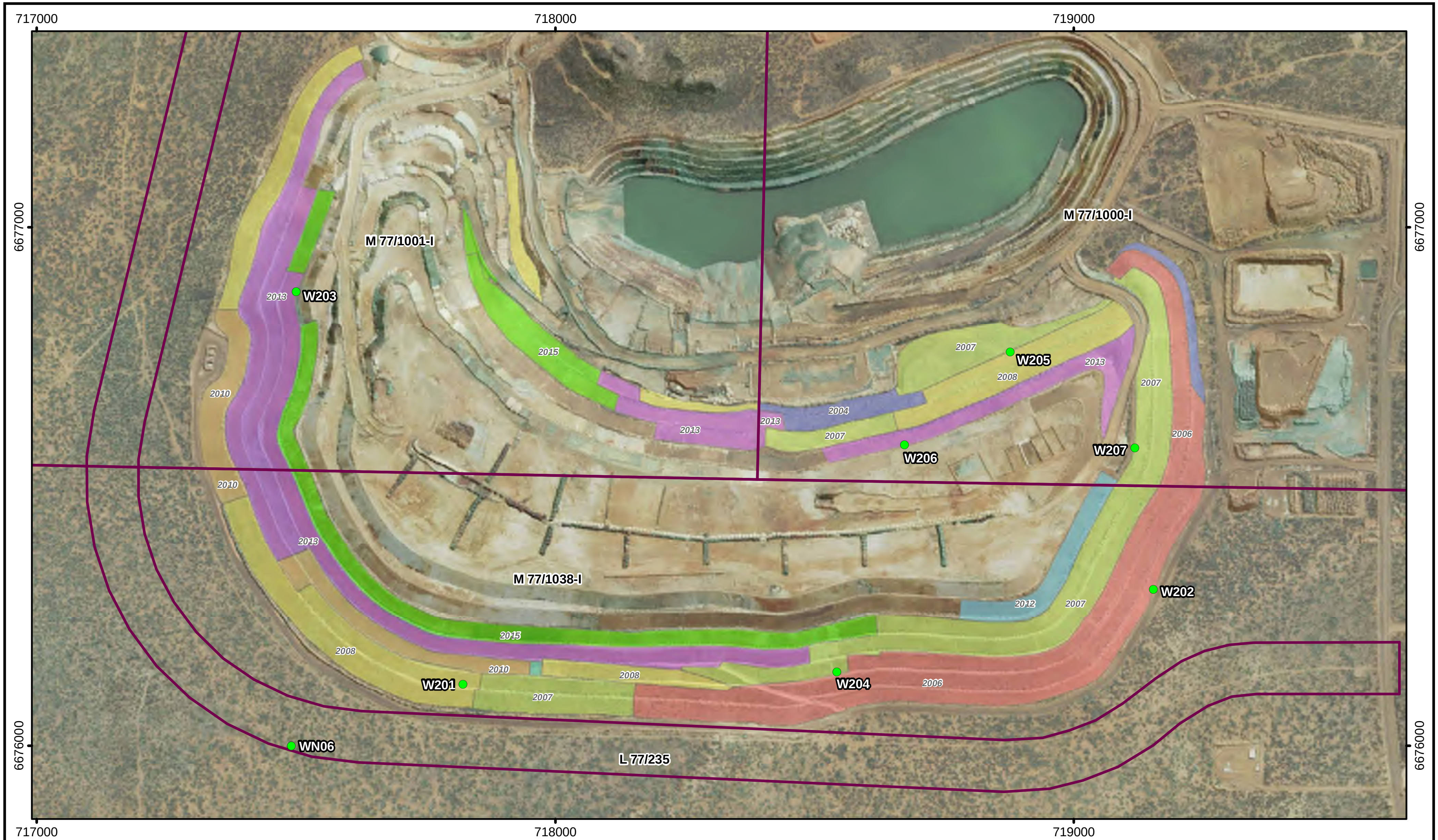
CAD Ref: g836ml289_W01

Date: April 2018 | Rev: A | A4

Author: D. Radovic

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

Windarling Range
Monitoring Transects



Legend
- Monitoring Transect
- Tenement

Rehab Year

2004	2006	2010
	2007	2012
	2008	2013
	2009	2015

N

0 100 200 m

Scale: 1:10,000
MGA94 (Zone 50)

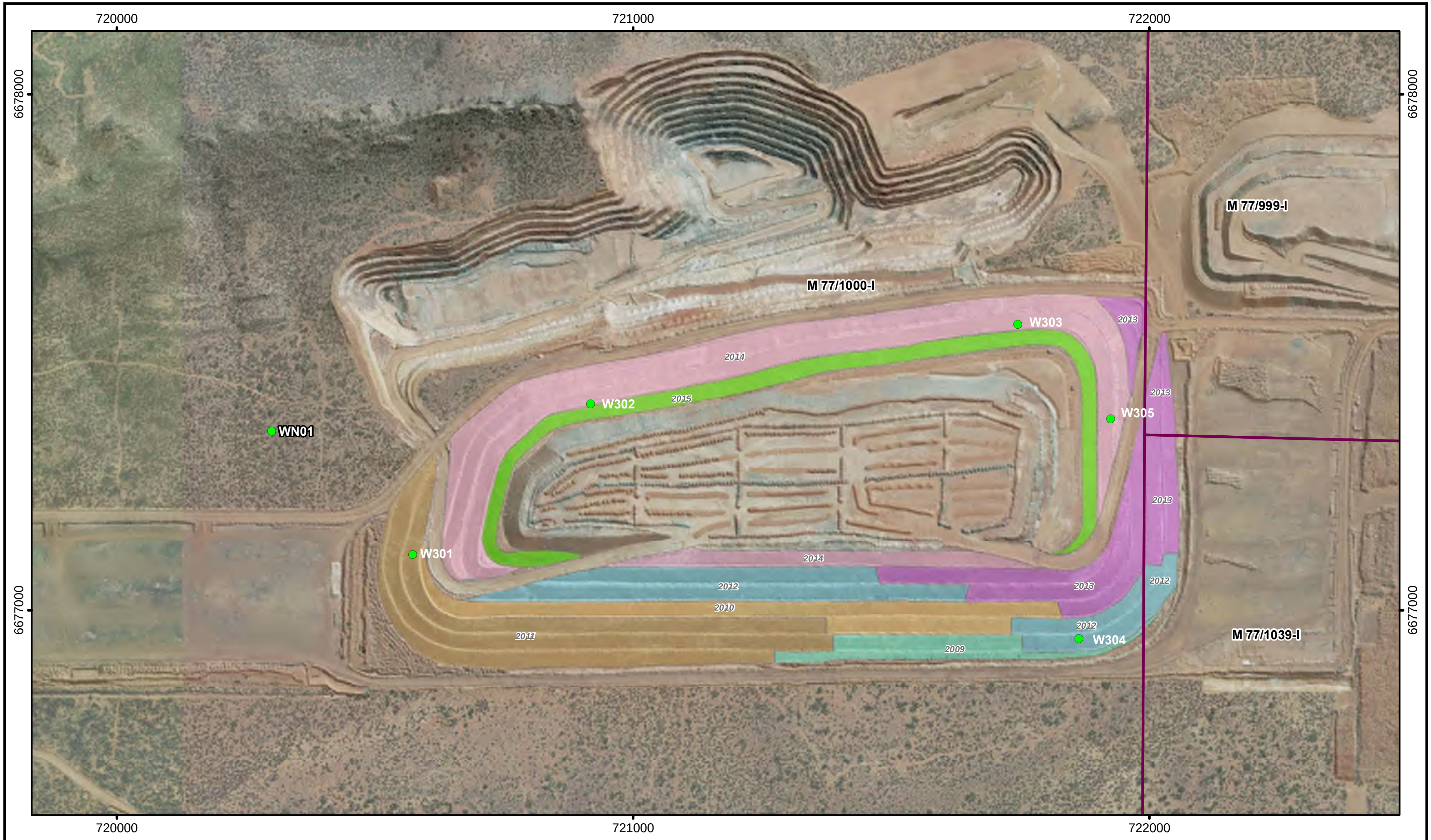
CAD Ref: g836ml289_W02

Date: April 2018 | Rev: A | A4

Author: D. Radovic

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

W2 Waste Dump Monitoring Transects



Legend

- Monitoring Transect
- Tenement

Rehab Year

- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015

N

0 100 200 m

Scale: 1:10,000
MGA94 (Zone 50)

CAD Ref: g836ml289_W03

Date: April 2018 | Rev: A | A4

Author: D. Radovic

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

W3 Waste Dump Monitoring Transects

Appendix 2

Photographic monitoring sites

2018 Photographic Monitoring

Following are the monitoring sites that were photographed only (rather than full monitoring being completed) during the 2018 monitoring program. Where available, a photo from the last monitoring is included to provide comparison with previous vegetation health.

Koolyanobbing Reference Sites

Site number:	**N 02**
Date:	1/11/2018
Vegetation description:	Salt lake fringing vegetation. *Hakea recurva* very open tall shrubland over *Dodonaea viscosa* open shrubland over mixed chenopod low open shrubs.
Vegetation condition:	Very good (historic disturbance)
Photograph 1:	N 02 West end 2018

Photograph 2: N 02 West end 2012

Site number:	N 04
Date:	1/11/2018
Vegetation description:	*Eucalyptus corrugata* very open woodland over *Acacia enervia, Hakea recurva* and *Eremophila clarkei* mid shrubland over mixed low shrubs and herbs.
Vegetation condition:	Very good (historic disturbance)
Photograph 1:	N 04 West end 2018

Photograph 2: N 04 West end 2012

Site number:	N 05
Date:	1/11/2018
Vegetation description:	Salt lake fringing vegetation. *Hakea recurva* very open tall shrubland over *Dodonaea viscosa* open shrubland over mixed chenopod low open shrubs.
Vegetation condition:	Very good (historic disturbance, rabbits)
Photograph 1:	N 05 South end 2018

Photograph 2:	N 05 South end 2012

Site number:	**N 06**
Date:	1/11/2018
Vegetation description:	*Acacia enervia* tall very open shrubland over *Hakea recurva, Eremophila scoparia, Senna artemisioides subsp. filifolia* and *Dodonaea viscosa* mid shrubland.
Vegetation condition:	Excellent
Photograph 1:	N 06 East end

Photograph 2:	N 06 West end (no previous photo available)

Site number:	N 08
Date:	1/11/2018
Vegetation description:	*Eucalyptus corrugata* open woodland over *Dodonaea viscosa*, *Senna artemisioides* subsp *filifolia* and *Eremophila scoparia* open shrubland.
Vegetation condition:	Excellent
Photograph 1:	N 08 East end 2018

Photograph 2:	N 08 East end 2012

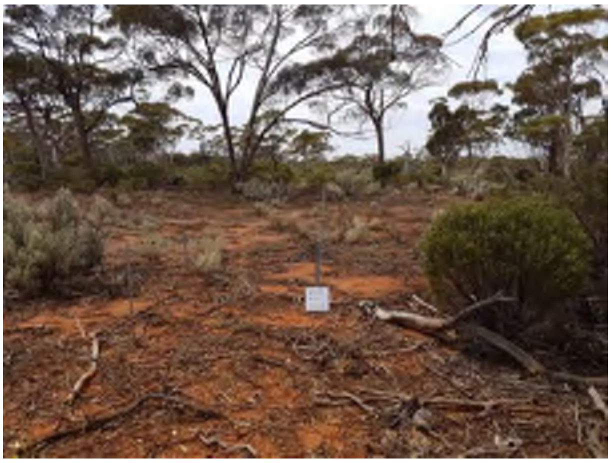
Site number:	N 09
Date:	1/11/2018
Vegetation description:	*Eucalyptus* woodland with occasional shrubs.
Vegetation condition:	Excellent
Photograph 1:	N 09 West end 2018

Photograph 2:	N 09 West end 2012

Site number:	**KN 01**
Date:	1/11/2018
Vegetation description:	*Eucalyptus oleosa* and *Eucalyptus longissima* mallee woodland over *Acacia* sp. Mt Jackson, *Eremophila oppositifolia* subsp. *angustifolia* tall shrubland over *Dodonaea lobulata*, *Eremophila* spp. and *Senna artemisioides* subsp. *filifolia* over mixed *Eremophila*, *Olearia* and *Maireana* low shrubs and herbs.
Vegetation condition:	Excellent
Photograph 1:	KN 01 East end 2018

Photograph 2:	KN 01 East end 2013

Site number:	KN 03
Date:	1/11/2018
Vegetation description:	*Eucalyptus corrugata* open woodland over *Eremophila* spp. tall and mid open shrubland over *Atriplex nummularia* and *Atriplex vesicaria* low open shrubland.
Vegetation condition:	Excellent
Photograph 1:	KN 03 West end 2018



Photograph 2:	KN 03 West end 2013

Site number:	KN 04
Date:	1/11/2018
Vegetation description:	*Eucalyptus loxophleba* low open mallee woodland over *Acacia* sp. Mt Jackson and *Allocasuarina ?acutivalvis* tall to mid shrubland over *Acacia*, *Dodonaea* and *Eremophila* shrubland over mixed low shrubs and herbs.
Vegetation condition:	Excellent (recent storm damage)
Photograph 1:	KN 04 West end 2018

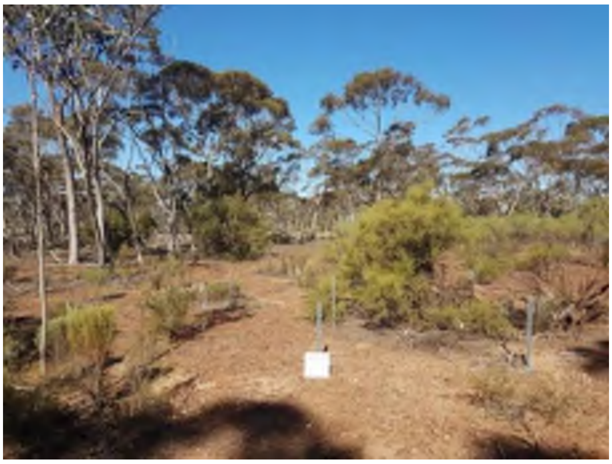
Photograph 2:	KN 04 West end 2013

Site number:	KN 05
Date:	1/11/2018
Vegetation description:	*Eucalyptus* transcontinentalis and *Eucalyptus corrugata* very open woodland over tall to mid sparse *Exocarpa aphyllus, Atriplex nummularia, Senna artemisioides* subsp. *filifolia* and *Eremophila spp.* mid to tall open shrubland over *Atriplex vesicaria* and mixed chenopod low shrubs.
Vegetation condition:	Very good (historic disturbance, evidence of cattle and rabbits)
Photograph 1:	KN 05 West end 2018

Photograph 2:	KN 05 West end 2013

Site number:	KN 13
Date:	1/11/2018
Vegetation description:	*Eucalyptus ?yilgarnensis* open woodland over *Acacia erinaceae, Senna artemisioides* subsp. *filifolia, Eremophila scoparia* with scattered *Exocarpus apyllus* and *Atriplex nummularia* mid open to sparse shrubland over *Atriplex vesicaria* and *Olearia meulleri* low sparse shrubs.
Vegetation condition:	Excellent
Photograph 1:	KN 13 East end

Photograph 2:	KN 13 West end (no prior photo)

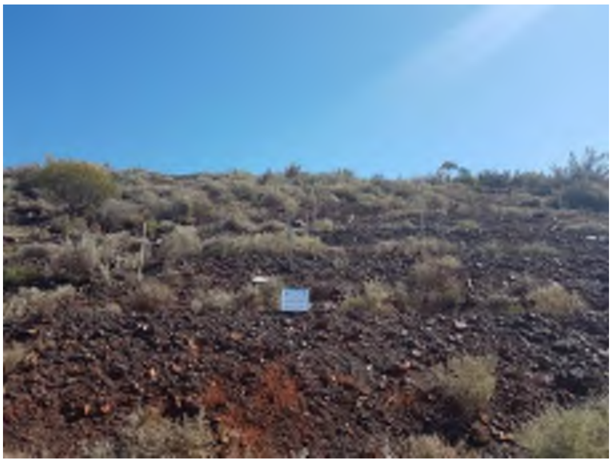


Koolyanobbing Waste Dump Rehabilitation Sites

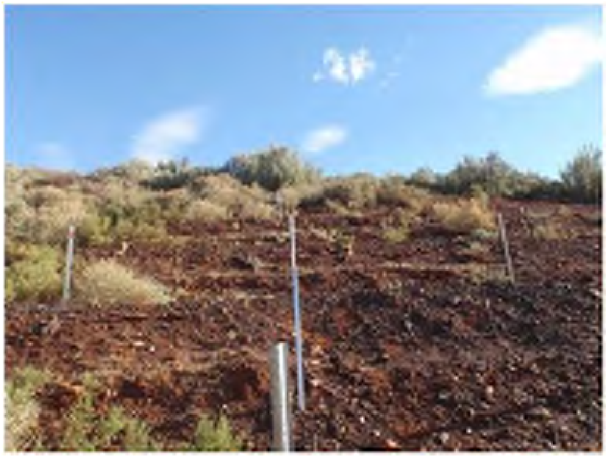
Site number:	**K 05**
Date:	1/11/2018
Vegetation description:	*Atriplex nummularia* very open shrubland over mixed chenopod shrubs and herbs.
Erosion:	Minor rilling throughout transect, appears stable. Severity = 1
Comments:	Limited species diversity but progress since last monitoring. Weeds: none noted.
Photograph 1:	K 05 West end 2018

Photograph 2:	K 05 West end 2012

Site number:	K 07
Date:	1/11/2018
Vegetation description:	*Senna artemisioides* subsp. *filifolia* and *Atriplex nummularia* very open shrubland over *Atriplex vesicaria* low shrubland over mixed chenopod low shrubs and herbs.
Erosion:	Minor rilling throughout transect, appears stable. Severity = 1
Comments:	No significant change since previous monitoring. Weeds: none noted.
Photograph 1:	K 07 East end 2018



Photograph 2: K 07 East end 2012



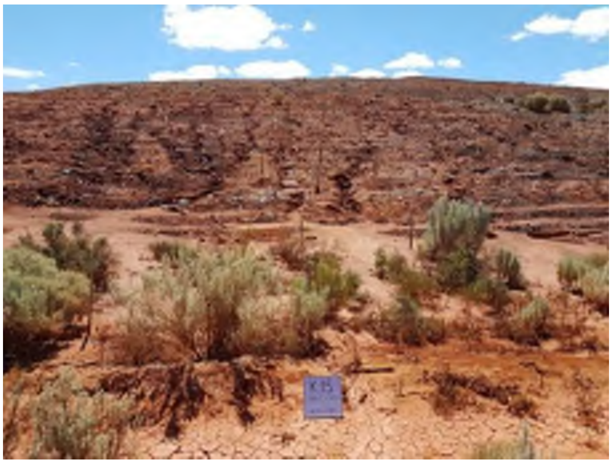
Site number:	K 10
Date:	1/11/2018
Vegetation description:	*Atriplex nummularia* very open shrubland over mixed chenopod shrubs and herbs.
Erosion:	Minor rilling throughout transect, appears stable. Severity = 1
Comments:	Limited diversity but vegetation has become more dense since last monitoring. Weeds: Ward's weed
Photograph 1:	K 10 East end 2018

Photograph 2: K 10 West end 2012

Site number:	K 13
Date:	1/11/2018
Vegetation description:	*Senna artemisioides* subsp. *filifolia* and *Atriplex nummularia* very open shrubland over *Atriplex vesicaria* low shrubland over mixed chenopod low shrubs and herbs.
Erosion:	Significant gullying on the north side of transect, minor rilling throughout. Severity = 2 – 4 (north side)
Comments:	Erosion has continued since previous monitoring. No significant change in vegetation. Weeds: Ward's weed
Photograph 1:	K 13 West end 2018

Photograph 2: K 13 West end 2012

Site number:	K 15
Date:	1/11/2018
Vegetation description:	Lower = *Atriplex nummularia* open shrubland over mixed chenopod shrubland/herbs Upper = *Atriplex* sp. very open low shrubland
Erosion:	Minor to moderate rilling and gullies throughout, Severity = 2
Comments:	Minimal vegetation establishment since last monitoring (newly rehabilitated). Soils are sodic soils and demonstrate poor stability as a result of inappropriate material placed on outer surface of dump prior to topsoil. Weeds: Ward's weed
Photograph 1:	K 15 East end 2018



Photograph 2:	K 15 East end 2012(?)

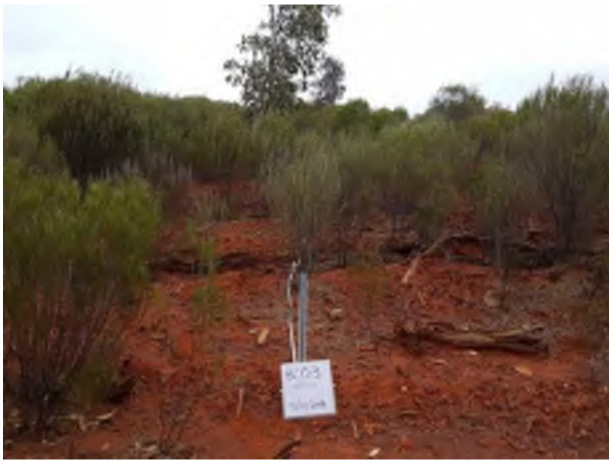
Site number:	A1 01
Date:	1/11/2018
Vegetation description:	Lower = *Eucalyptus loxophleba* very open low woodland over *Acacia accuminata* and *A. hemiteles* shrubland. Upper = *Eucalyptus griffithsii* (or ?*corrugata*) over *Atriplex nummularia* and *A. vesicaria* shrubland over mixed chenopod low shrubs and herbs.
Erosion:	Minor rilling. Severity = 1
Comments:	Very good progress of revegetation since previous monitoring. Weeds: scattered ruby dock; *Sonchus asper* (sow thistle) abundant at lower end of transect.
Photograph 1:	A1 01 West end 2018

Photograph 2: A1 01 West end 2013(?)

Site number:	**A1 02**
Date:	1/11/2018
Vegetation description:	Lower = *Acacia acuminata and Senna art. fil shrubland* over mixed chenopod low shrubs and herbs Upper = *Atriplex ?vesicaria* and *Maireana brevifolia* low shrubland over mixed chenopod low shrubs and herbs.
Erosion:	Minor erosion on upper portion of slope
Comments:	Good progress of revegetation since previous monitoring. Weeds: scattered ruby dock.
Photograph 1:	A1 02 North end

Photograph 2: A1 02 North end 2013(?)

Site number:	**BC 03**
Date:	1/11/2018
Vegetation description:	Lower = Scattered *Eucalyptus griffithsii* and *Eucalyptus* sp. (juv) over *Acacia accuminata* shrubland. Upper = *Acacia acuminata*, *Eremophila clarkei* and *Atriplex* sp. low open shrubland over mixed chenopod low shrubs and herbs.
Erosion:	Minor rilling. Severity = 1
Comments:	Good progress since last monitoring. Weeds: scattered ruby dock and sow thistle.
Photograph 1:	BC 03 North end



Photograph 2: BC 03 North end 2013(?)

Site number:	BC 04
Date:	1/11/2018
Vegetation description:	Lower = *Acacia acuminata*, *Senna artemisioides* subsp. *filifolia* and *Dodonaea lobulata* very open shrubland over mixed chenopod low shrubland/herbs Upper = *Eremophila scoparia* very open shrubland over mixed chenopod low shrubland/herbs.
Erosion:	Minor erosion on upper portion of slope. Severity = 1
Comments:	Weeds: scattered ruby dock and sow thistle.
Photograph 1:	BC 04 North end 2018

Photograph 2:	BC 04 South end 2018 (no previous photo)

Mt Jackson Reference Sites

Site number:	**JN 02**
Date:	1/11/2018
Vegetation description:	Scattered *Eucalyptus ebbanoensis* low open woodland over *Allocasuarina eriochlamys* dense shrubland over mixed low very open to sparse shrubland.
Vegetation condition:	Excellent
Photograph 1:	JN 02 West end 2018

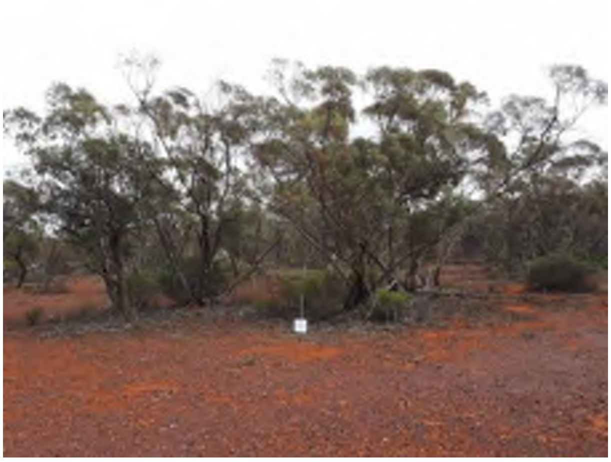
Photograph 2:	JN 02 West end 2014

Site number:	JN 03
Date:	1/11/2018
Vegetation description:	*Eucalyptus ebbanoensis* low open woodland over *Acacia acuminata*, *Beyeria* sp. and *Scaevola spinescens* mid open shrubland over *Olearia muelleri* and *Westringia cephalantha* low open shrubland.
Vegetation condition:	Excellent
Photograph 1:	JN 03 South end 2018

Photograph 2:	JN 03 South end 2014

Site number:	**JN 04**
Date:	1/11/2018
Vegetation description:	*Eucalyptus ebbanoesis* low open woodland over *Acacia acuminata* and *Eremophila oppositifolia* mid to tall open shrubland over *Olearia* and *Ptilotus* low shrubs and herbs.
Vegetation condition:	Excellent
Photograph 1:	JN 04 North end 2018

Photograph 2: JN 04 South end 2018 (no previous photo)

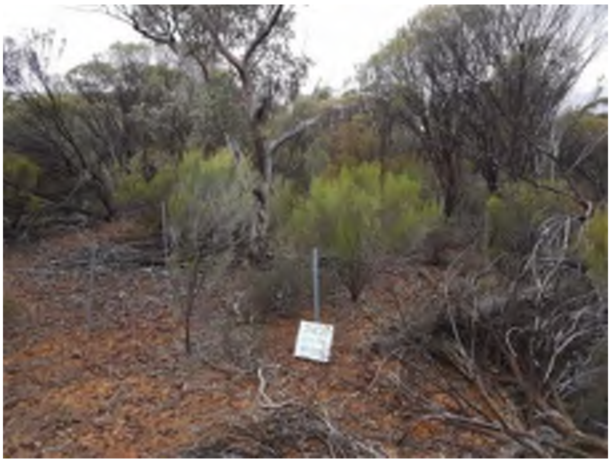


Site number:	JN 05
Date:	1/11/2018
Vegetation description:	*Eucalyptus ebbanoensis, Brachychito gregorii* and *Banksia arborea* very open woodland over *Allocasurina acutivalvis* and *Acacia* sp. Mt Jackson tall shrubland over *Eremophila* shrubs over mixed low shrubs and herbs.
Vegetation condition:	Excellent
Photograph 1:	JN 05 East end 2018

Photograph 2:	JN 05 West end 2018 (no suitable comparative photo available)

Site number:	JN 08
Date:	1/11/2018
Vegetation description:	*Eucalyptus ebbanoensis* very open woodland over *Allocasurina acutivalvis and Acacia acuminata* mid to tall shrubland over mixed low shrubs.
Vegetation condition:	Excellent
Photograph 1:	JN 08 East end 2018

Photograph 2:	JN 08 West end 2018 (no suitable comparative photo available)



Site number:	JN 09
Date:	1/11/2018
Vegetation description:	Scattered *Eucalyptus ebbanoensis* low open woodland over *Allocasuarina ?acutivalvis* mid to tall closed shrubland over mixed low shrubs and herbs.
Vegetation condition:	Excellent
Photograph 1:	JN 09 West end 2018

Photograph 2: JN 09 West end 2014

Site number:	JN 11
Date:	1/11/2018
Vegetation description:	*Eucalyptus ebbanoensis* very open woodland over *Allocasurina acutivalvis, Acacia* sp. Mt Jackson *and Acacia acuminata* mid to tall shrubland over mixed low shrubs.
Vegetation condition:	Excellent
Photograph 1:	JN 11 North end 2018

Photograph 2: JN 11 North end 2014

Site number:	JN 12
Date:	1/11/2018
Vegetation description:	*Eucalyptus ebbanoensis* very open woodland over *Allocasurina acutivalvis* and *Grevillea obliquistigma* subsp. *obliquistigma* mid to tall shrubland over mixed low shrubs and herbs.
Vegetation condition:	Excellent
Photograph 1:	JN 12 North end 2018

Photograph 2:	JN 12 North end 2014

Mt Jackson Waste Dump Rehabilitation Sites

Site number:	**J2 02**
Date:	1/11/2018
Vegetation description:	Acacia acuminata and Acacia sp. Mt Jackson tall shrubland over Acacia, Dodonaea low shrubland over mixed low shrubs and herbs.
Erosion:	Minimal rilling. Severity = <1
Comments:	No significant change since previous monitoring.
Photograph 1:	J2 02 South end 2018

Photograph 2:	J2 02 South end 2014

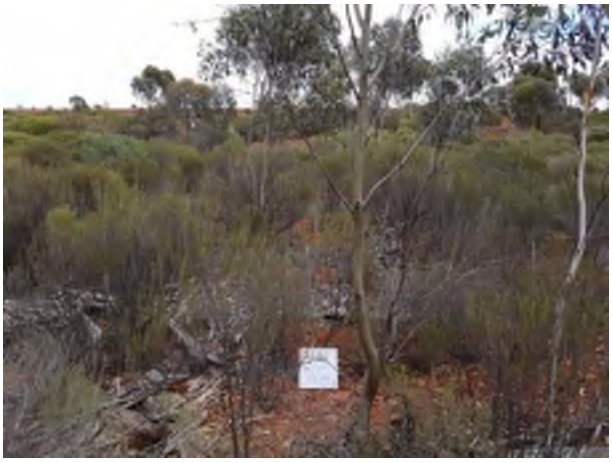
Site number:	J2 03
Date:	1/11/2018
Vegetation description:	*Acacia acuminata* and *Acacia effusifolia* mid shrubland over mixed spares low shrubs and herbs.
Erosion:	Minimal rilling. Severity = <1
Comments:	No significant change since previous monitoring. Acacia shrubs have grown, still sparsely vegetated.
Photograph 1:	J2 03 North end 2018

Photograph 2: J2 03 North end 2014

Site number:	J3 01
Date:	1/11/2018
Vegetation description:	*Eucalyptus ?ebbanoensis* very open woodland over *Acacia acuminata, Acacia effusifolia, Hakea minyma* and *Grevillea obliquistigma* mid shrubland over mixed low shrubs and herbs.
Erosion:	Nil
Comments:	Vegetation is well established but sparse cover.
Photograph 1:	J3 01 North end 2018

Photograph 2: J3 01 North end 2014(?)

Site number:	**J3 02**
Date:	1/11/2018
Vegetation description:	*Eucalyptus ?ebbanoensis* very open woodland over *Acacia acuminata*, *Acacia* sp. Mt Jackson, *Allocasuarina acutivalvis* and *Grevillea obliquistigma* mid shrubland over mixed low shrubs and herbs.
Erosion:	Nil
Comments:	Vegetation is well established and appears to be self-sustaining.
Photograph 1:	J3 02 East end



Photograph 2:	J3 02 West end (no previous photo suitable for comparison)

Site number:	**WN 01**
Date:	1/11/2018
Vegetation description:	*Eucalyptus longissimi* open low woodland over *Acacia effusifolia* and *Acacia cockertoniana* tall shrubland.
Vegetation condition:	Excellent
Photograph 1:	WN 01 East end 2018

Photograph 2:	WN 01 East end 2014(?)

Site number:	**WN 03**
Date:	1/11/2018
Vegetation description:	*Eucalyptus longissimi* open low woodland over *Acacia effusifolia* and *A. cockertoniana* tall shrubland.
Vegetation condition:	Excellent
Photograph 1:	WN 03 South end 2018

Photograph 2:	WN 03 South end 2014(?)

Site number:	**WN 05**
Date:	1/11/2018
Vegetation description:	*Eucalyptus corrugata* and *E. longissimi* woodland over *Acacia effusifolia, A. cockertoniana and Atriplex nummularia* mid open shrubland.
Vegetation condition:	Excellent
Photograph 1:	WN 05 South end 2018

Photograph 2: WN 05 South end 2014(?)

Site number:	WN 07
Date:	1/11/2018
Vegetation description:	*Acacia aneura* and *Acacia ramulosa* mid to tall shrubland over sparse low shrubs and herbs.
Vegetation condition:	Excellent
Photograph 1:	WN 07 North end

Photograph 2: WN 07 North end 2014(?)

Site number:	WN 08
Date:	1/11/2018
Vegetation description:	*Acacia aneura* and *Acacia ramulosa* mid to tall shrubland over sparse low shrubs and herbs.
Vegetation condition:	Excellent
Photograph 1:	WN 08 South end 2018

Photograph 2:	WN 08 South end 2014(?)

Site number:	WN 10
Date:	1/11/2018
Vegetation description:	*Acacia cockertoniana* and *Acacia aneura* tall shrubland over *Eremophila* spp. and *Olearia humilis* low open shrubland.
Vegetation condition:	Excellent
Photograph 1:	WN 10 West end 2018

Photograph 2:	WN 10 West end 2014(?)

Site number:	**WN 11**
Date:	1/11/2018
Vegetation description:	*Acacia effusifolia* tall shrubland over *Amphipogon caricinus, Prostanthera althoferi and Solanum orbiculatum* low sparse shrubland.
Vegetation condition:	Excellent
Photograph 1:	WN 11 West end 2018

Photograph 2:	WN 11 West end 2014(?)

Site number:	WN 12
Date:	1/11/2018
Vegetation description:	*Acacia aneura* and *Acacia effusifolia* tall shrubland over *Eremophila clarkei, Scaevola spinescens* and *Philotheca brucei* low shrubland over mixed low shrubs and herbs.
Vegetation condition:	Excellent
Photograph 1:	WN 12 East end

Photograph 2:	WN 12 East end 2014(?)

Site number:	WN 13
Date:	1/11/2018
Vegetation description:	*Acacia cockertoniana, A. aneura* and *A. ramulosa* tall shrubland over *Eremophila*, *Dodonaea*, *Philotheca* and *Olearia* low open shrubland.
Vegetation condition:	Excellent
Photograph 1:	WN 13 South end 2018

Photograph 2: WN 13 South end 2014

Site number:	WN 14
Date:	1/11/2018
Vegetation description:	*Eucalyptus corrugata* and *E. longissimi* open woodland over *Acacia effusifolia* and *A. cockertoniana* mid to low open shrubland.
Vegetation condition:	Excellent
Photograph 1:	WN 14 North end 2018

Photograph 2:	WN 14 North end 2014

Windarling Waste Dump Rehabilitation Sites

Site number:	**W2 03**
Date:	1/11/2018
Vegetation description:	*Acacia aneura* and *Senna* sp. mid open shrubland over *Maireana georgei*, *Maireana tomentosa* and *Salsola australis* low open shrubland over *Ptilotus nobilis* low sparse shrubland
Erosion:	Minor rilling. Severity = 1
Comments:	Low vegetative cover, perennial species more established. Weeds = scattered *Centaurea melitensis*
Photograph 1:	W2 03 East end 2018

Photograph 2:	W2 03 East end 2014(?)

Site number:	W2 04
Date:	1/11/2018
Vegetation description:	*Acacia aneura*, *Grevillea juncifolia* and *Scaevola spinescens* mid open shrubland over *Maireana georgei*, *Maireana tomentosa* and *Sclerolaena cuneata* low sparse shrubland over *Ptilotus nobilis* and *Ptilotus obovatus* low sparse shrubland.
Erosion:	Minor rilling, mainly upper level. Severity = 1-2
Comments:	Low vegetative cover, perennial species more established. Weeds = scattered *Centaurea melitensis*
Photograph 1:	W2 04 South end 2018

Photograph 2: W2 04 South end 2014(?)

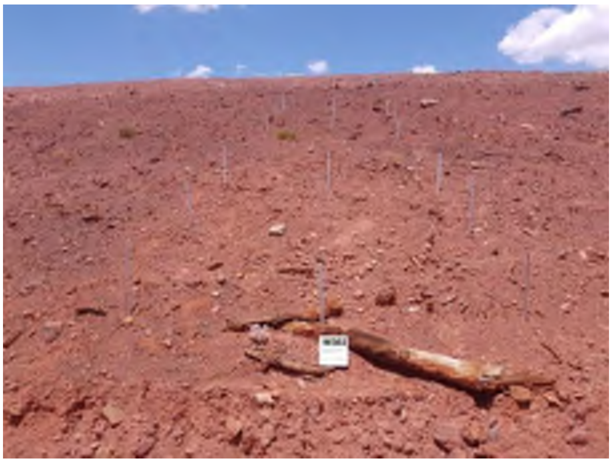
Site number:	**W2 06**
Date:	1/11/2018
Vegetation description:	Lower: *Acacia caesaneura, Acacia fuscaneura* and *Acacia ramulosa* low open shrubland with scattered *Atriplex nummularia* over mixed low shrubs and herbs. Upper: *Acacia ramulosa* and *Senna artemisioides* open shrubland over mixed low shrubs and herbs.
Erosion:	Minor rilling. Severity = 1
Comments:	Low vegetative cover, perennials have established since last monitoring. Weeds: none noted.
Photograph 1:	W2 06 South end 2018

Photograph 2:	W2 06 South end 2014(?)

Site number:	W2 07
Date:	1/11/2018
Vegetation description:	Lower = Acacia caesaneura and Acacia fuscaneura shrubland over mixed chenopod shrubs Upper = Acacia acuminata and Senna artemisioides subsp. filifolia shrubland over chenopod shrubs
Erosion:	Moderate erosion at lower section of top level (Plot 3) Severity = 2
Comments:	No significant change since previous monitoring. Weeds: none noted.
Photograph 1:	W2 07 West end 2018

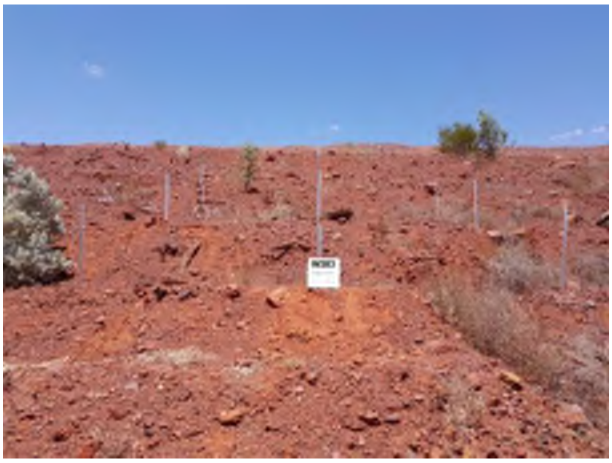
Photograph 2:	W2 07 West end 2014

Site number:	W3 02
Date:	1/11/2018
Vegetation description:	Minimal vegetation present.
Erosion:	Minor rilling on lower slope, no significant gullies. More rilling on upper slope.
Comments:	Newly established.
Photograph 1:	W3 02 North end 2018

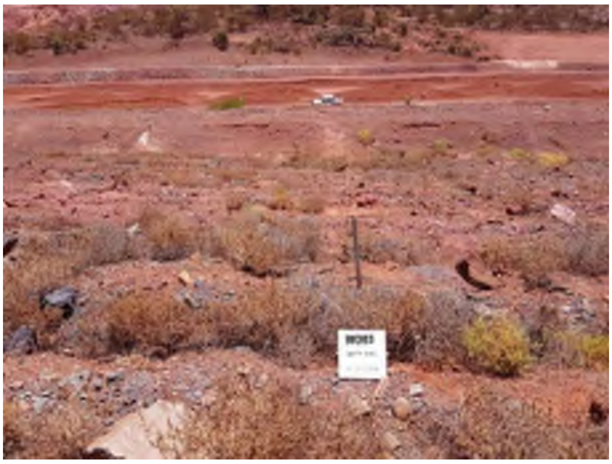


Photograph 2:	W3 02 South end 2018 (no previous monitoring undertaken).

Site number:	**W3 03**
Date:	1/11/2018
Vegetation description:	*Atriplex nummularia*, *Acacia sp*. and *Senna artemisioides* subsp *filifolia* sparse shrubland over *Salsola australis* and mixed chenopod herbs.
Erosion:	Minor rilling throughout. Severity = 1
Comments:	No previous monitoring undertaken
Photograph 1:	W3 03 North end 2018



Photograph 2:	W3 03 West end 2018 (no previous monitoring)



Appendix 3
Monitoring site data

Provided separately as Excel files.